Reflections on NUMERACY *and* STREAMING *in mathematics education*

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This article comes largely from observations made on-the-job while teaching mathematics in a government high school in the ACT. The issues canvassed will be familiar to those who have considered the arguments for and against ability grouping in mathematics education. It is speculative in nature, hinting at a synthesis of opposing views in the ability-grouping debate and ending with a proposal about how the practice of streaming might be aligned better with numeracy outcomes. (For a summary of the ability-grouping debate see the articles by Thornton and Coombes mentioned in the reference list.)

Numeracy

Numeracy as a concept has been evolving over the past 50 years. It has become differentiated from its erstwhile twin literacy. It has come to include more than just number in the spectrum of mathematical ideas, and it has become a personal attribute very much dependent on the context in which the numerate individual is operating.

In the words of Lynn Arthur Steen (2000), professor of mathematics at St Olaf College in Northfield, Minnesota, USA, “Numeracy has no special content of its own, but inherits its content from its context.” Moreover, “Numeracy is driven by issues that are important to people in their lives and work.”

Closer to home, the report *Numeracy = everyone’s business* (DEETYA, 1997) presents some common understandings about the meaning of numeracy, structuring part of its discussion around the idea that “numeracy involves using some mathematics to achieve some purpose in a particular context”. Among other things, the report states that “to be numerate is to use mathematics effectively to meet the general demands of life at home, in paid work, and for participation in community and civic life”. This is the definition adopted by the AAMT in its document “Policy on Numeracy Education in Schools” which goes on to say:

> In school education, numeracy is a fundamental component of learning, 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 (numerical, spatial, graphical, statistical and algebraic);
> - mathematical thinking and strategies;
> - general thinking skills; and
> - grounded appreciation of context.

Distilling from these descriptions of numeracy, it seems fair to say that to be numerate is to have the mathematical tools appropriate to the tasks one is engaged in from day to day, and the inclination to use them.

Some day-to-day tasks are optional. Not everyone has to be engaged in plotting the trajectories of dangerous asteroids into the future of the solar system. Those who are would have the inclination to know and use the mathematics appropriate to their specialised tasks.

Other day-to-day tasks are more-or-less obligatory for nearly everyone. It is clearly desirable that most people should possess both the mathematical tools appropriate to these common tasks and the inclination to use them. For when the inclination is lacking, the tools are in effect left rusting in the box.

Inclination

As Thelma Perso (2006, p. 36) recently pointed out, "knowing some mathematics must precede the choice to use it or not". It could also be argued that without this inclination to use mathematics, the student will absorb little if any mathematics in the first place.

Few teachers would dispute that the desire to know and understand is a necessary precondition for learning. This desire for learning seems closely related to, if not identical with, the inclination to use mathematics (in the numeracy sense). Thus, mathematical knowledge and the inclination to use it are bound in a loop. They are interdependent, each motivating the other.

Where are we ever going to need this?

When students utter the familiar question, "When are we ever going to use this?" about the relevance of the current topic in their mathematics course, one is tempted to give an honest but unhelpful answer along the lines of, "You will need it next week in the test," or, "Probably never but you have to learn it anyway," or, "Employers want people who are good at mathematics even though the job may not require much of it," or, "It will be assumed knowledge in your next mathematics course."

I believe students who ask this question are not simply being lazy or difficult, but are signalling the existence of a serious shortcoming in the way mathematics education is being delivered to them. They are saying something significant about their interests, their drives and indeed their inclination to choose and use particular mathematical tools.

Too often we teachers find ourselves trying to deliver prescribed content to classes of students that include some who have a very tenuous interest in it. This cannot lead to good outcomes for the students or for the teacher.

Why do we study mathematics?

In an effort to provide an honest and helpful answer to the question of why mathematics should be studied, I devised a questionnaire — really a disguised piece of propaganda — that presented three positive reasons for studying mathematics and asked students to rate each on a scale of 1 to 10 according to its importance for them personally. The reasons for studying mathematics that I gave in my questionnaire are reproduced below in a slightly revised form.

1. Mathematics is part of our culture

From diagrams drawn in the sand by ancient geometers to modern ideas about fractals and chaos, mathematics has been an essential component in our evolving culture. Writers, filmmakers, musicians and poets use mathematical metaphors, and parents teach their children basic ideas about number and space from an early age. The astonishing developments in our understanding of the physical world over the past one thousand years, accelerating in the nineteenth and twentieth centuries, would have been unthinkable without ideas from mathematics to guide and clarify our perceptions. The sciences — physical, biological and social — depend on mathematics, as do the practical applications of scientific discovery created by engineers and manufacturers.

2. Mathematics is useful

Many employers look for a level of competence in mathematics when they are recruiting new staff, even when the job does not directly require high-level mathematical skills. This is because training in mathematics helps one to be logical and analytical, and to be a problem solver. Many jobs do require specific mathematical skills: accountant, banker, carpenter, draughtsman, electrician, etc. As well, there are many day-to-day or leisure time activities in which the need for some mathematical skills may arise: catching a bus, building a shed, designing a quilt, doing the shopping, and so on. The technological gadgets we use every day depend for their existence on people who understand the mathematics behind them.

3. Mathematics is interesting

There are people for whom mathematics is fascinating for itself — regardless of its practical value. Mathematical discoveries are often made many years before anyone finds a practical use for them. This is a human characteristic. We do mathematics for the same sorts of reasons that inspire us to make art, excel in sport or climb mountains. Humans are curious about their world. We like to discover how things work, we like to invent tools to increase our understanding, and we like to make objects, abstract and concrete, that are pleasing to contemplate.

The initial motivation for this device was to make my students in Years 8 and 9 aware of some good reasons for studying mathematics. Soliciting their opinions about the "good reasons" was, at the time, little more than a hook to secure their participation. Two years on, I am now of the view that the students' opinions were in fact the more valuable part of the exercise.

Value space

Knowledge of where a student stands in what might be called mathematical value space, the spectrum of opinions about where mathematics fits in the scheme of things, is likely to make it easier to teach in a way that helps the student to remain receptive to mathematical ideas and to see mathematics as something that might be applied profitably in real situations. This may be obvious to the point of being fatuous but it is worth saying because the structures that are often in place in schools, and in school systems, can make it difficult to act meaningfully on data of this kind.

Streaming by ability

The practice of streaming students according to their supposed ability levels is widespread. For teachers, streaming has clear advantages in that they can pitch their lessons to groups of roughly similar students. It has advantages for students in that they can be confident that the content will be at about the right level of difficulty for them.

On the other hand this kind of streaming stratifies students and labels them with words that mean 'bright', 'mediocre' and 'slow'. Students come to see themselves as belonging to a particular stream and will wear their stream label as a badge. In later years, if they were not in the top stream, they may boast about their ineptitude at mathematics.

Streaming by ability level tends to make it difficult for teachers to use information about students' opinions of the place of mathematics in their world, because the stratification itself has already coloured the students' views, making the subject unattractive and inclining them to the belief that mathematics is hardly relevant at all in their world. For these students, the damage done by ability streaming to their self-image with respect to mathematics has become a hindrance to their numeracy.

A blunt instrument

If, again referring to Thelma Perso's article (2006, p.39), mathematics education is to have a "numeracy focus" then it may make more sense to stream students not by measuring their mathematical abilities but by discovering their location in the space of values or beliefs about the place of mathematics in their personal world.

The instrument described above provided a first approximation towards locating students in this space. If it were to be used again, the wording of the questionnaire would need to be condensed or simplified for younger or less literate students, but the aim would remain to help students identify their dominant modes of approach to the subject of mathematics.

Unfortunately perhaps, the 49 responses I obtained from a narrow band of students using my questionnaire, suggested that most students are likely to place themselves in the mathematics-as-kit-of-tools region. Testing on a larger sample would be needed to confirm this but it is clear that an alternative streaming of students based only on their positions in mathematical value space would not be quite what is needed.

(One might speculate about why relatively few of the students I tested valued the cultural and scientific aspects of mathematics, but the fact that the instrumental view of mathematics did appeal strongly to many of them has implications for the way the subject is taught and for the design of courses.)

To sharpen the streaming or course selection process, students would also need to consider their vocational aspirations and other factors. Better instruments could be devised to assist students, their parents and their teachers in understanding students' preferred modes of approach to the subject of mathematics and their reasons for studying it, and each of these stakeholders would need to be involved in any subsequent decision making.

An alternative

While it is certainly true that students differ in their purely mathematical abilities, or more accurately, their mathematical inclinations, this fact should not be allowed to get in the way of their numeracy development. If the numerate are those who possess mathematical tools appropriate to their daily activities and are confident about using them, then numeracy will mean different things for different people according to their interests and lifestyles.

Given appropriate guidance and consultation, having identified their dominant modes of approach to mathematics and their vocational aspirations, students (with the agreement of parents) might then select courses that they believe likely to meet their needs: courses with descriptive titles like Mathematical Applications, Mathematics for Public Administration, Mathematics for the Trades and Industry, Mathematics for Commerce, Specialist Mathematics, Mathematics for Research and Technology, Workforce Mathematics, and so on. Senior Secondary Colleges in the ACT already use two of these titles. Another is the name of a course running in the school where I worked, until recently, for a select group of students who would otherwise be labelled "Level 3". I see no reason why similar nomenclature could not be extended throughout the secondary schooling years.

There would be no question of attempting to deceive students that the intellectual requirements for each course were the same. They would know that some courses would be "harder" than others. But their focus may well shift away from concerns about their level of mathematical cleverness towards the issue of how different courses are best suited to meet their needs.

Conclusion

In summary, mathematics is an item in our heritage that many people evaluate negatively. It seems natural to assume that having negative feelings about mathematics and one's mathematical ability, implies a reluctance to use mathematics and hence a failure to be fully numerate.

If it is occasionally the case that a person's disdain for mathematics dates from high school mathematics experiences, the explanation for this could lie at least partly in the practice of streaming students into ability levels.

Streaming has advantages that we would want to retain but it sends an unfortunate message to students in the lower strata. A better scheme for streaming students is needed — one that does not interfere with the goal of turning out students with the mathematical equipment they are genuinely likely to need and also the inclination to use it. Such a scheme might be based on students' desires and aspirations rather than on dubious measures of their mathematical aptitude.

My direct observations on these matters are necessarily limited. Further work by practitioners and researchers is needed to ascertain the extent to which ability streaming may be an impediment to numeracy development, and to create alternative curriculum approaches.

References

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Investigation Ideas

- A Fruit Machine has two drums each containing 3 apples, 2 oranges and 1 banana. If you wanted the user to have fun without losing much money, what combinations would you organise to provide a payment and what would the payment be? What if there were three wheels on the machine?