What qualities does an excellent teacher of mathematics have?

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Professional Development and the Quality of Teaching

The idea of excellent teaching, or excellent teachers, is not new. All students can articulate the qualities they would like in such a teacher, and the lucky ones can remember being taught by one. However, how much agreement is there about what constitutes excellent teaching in mathematics? Is it worth trying to develop a consensus view about excellence in teaching mathematics? Who would benefit?

In this keynote I will describe the work of the Australian Association of Mathematics Teachers (AAMT)/Monash University research project on excellence in teaching mathematics, and discuss the issues with which the project is grappling. (My thanks for assistance with the preparation of this keynote are due to Barbara Clarke, Will Morony, and Sue Bennett). First however it is useful to get some perspective on the area of teaching quality. For many years the main concern about teaching quality was to ensure the quality of entrants into the profession. Teacher training institutions carried the main responsibility for these standards, with the help of cooperating teachers in the schools. Governments and other employers also had their views about the qualities needed for their beginning teachers, and teacher registration
was the instrumental mechanism for standardising the procedure for recognising those qualities.

Meanwhile in-service and professional development activities have been developing largely on an optional basis. They are optional in two senses: that anyone can offer them, and also that any teacher can participate in them. Whether or not they have always been in the best interests of either individual teachers, or the profession, is a moot point.

Over the past 20 years there have been various reform developments, most of which have been designed to develop the quality, or the kind, of mathematics teaching considered desirable in schools. One of the most influential projects of that kind culminated in the Cockcroft Report (Cockcroft, 1982). In it was a famous paragraph, number 243 which described “the elements which need to be present in successful mathematics teaching to pupils of all ages” (p.71). These were “exposition, discussion, appropriate practical work, problem solving, investigation, consolidation and practice”. This list was determined by the influential Cockcroft Committee, and immediately translated into governmental recommendations in several Commonwealth countries including Australia. The idea of ‘good practice’ was firmly established in mathematics educators’ minds, as was the idea that governments could, and should, be able to insist on what they claimed to be good practice.

At the same time, the idea behind much professional development activity was the idea of ‘reflective practice’ – that what is important for professional development is that individual teachers reflect on their practice, perhaps as a precursor to improving it. In some sense this idea is in opposition to the previous one, and it also reflected in some ways the concerns of those mathematics teachers who considered themselves professionals, and who felt that it was none of the government’s business to be telling them what good teaching was.

**Advanced Certification and Standards-based Professional Development**

As employers of teachers, all Australian governments now concern themselves with more than just the entry requirements for teaching. All now offer teachers some form of advanced certification e.g. Leading Teacher status in Victoria, Advanced Skills Teacher status in South Australia, Master Teacher status in Northern Territory. These certification arrangements carry with them
a modest increase in salary, and as such are intended to reward senior and experienced teachers in order to encourage them to remain in teaching.

In each case however, the selection criteria of professional standards used are generic rather than subject specific. They thus ignore the specific attributes and criteria necessary to recognise excellence in the teaching of mathematics. They assume that the qualities needed to teach mathematics well are the same as those needed for any other subject. A further development has been the requirement of improved accountability in teaching together with performance reviews.

However, what has been growing over the recent years has been a realisation of the need to bring together the professional capabilities of the subject associations, who have been busily developing their programs of in-service education, with the advanced certification movement within government and employer groups.

In the USA, this has been happening for more than a decade. There has been a powerful development of the standards movement relating to ‘excellent’ or highly accomplished teaching, and the National Board for Professional Teaching Standards has been established to systematise and carry forward this work. Its mission is: “to establish high and rigorous standards for what accomplished teachers should know and be able to do, and to develop and operate a national, voluntary system to assess and certify teachers who meet those standards” (National Board for Professional Teaching Standards, 1989).

Since the NBPTS has been operating, there have developed two parallel systems of professional development, as outlined by Ingvarson (1998), namely the governmental funded and determined system and the professional development offered by the subject associations, like the National Council of Teachers of Mathematics (NCTM) and the Mathematical Association of Victoria (MAV), that has become increasingly systematised.

The two systems are outlined in Table 1, after Ingvarson (1998), and the stark differences can be easily seen.

The feeling was therefore growing that it was time for Australia to develop its own system of professional certification. As in the USA, if education is to be accepted as a profession, there is a need to articulate ‘professional standards’ (Australian Senate Employment, Education and Training Reference Committee, 1998).
**Table 1: Professional Development comparisons**

<table>
<thead>
<tr>
<th>Locus of governance and control</th>
<th>Traditional PD system</th>
<th>Standards-based PD system</th>
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<tbody>
<tr>
<td></td>
<td>Based on Government and employer policies and priorities. Usually short-term</td>
<td>Based on profession-defined teaching standards and expertise. Long-term, stable.</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Providers</th>
<th>Employers, universities, and private consultants</th>
<th>Teacher associations. District/university collaborations</th>
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</table>

<table>
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<tr>
<th>Incentives and links to career structures</th>
<th>Weak – mainly intrinsic. Compliance with directives. Weak links to career stages.</th>
<th>Extrinsic and intrinsic rewards. Linked to career and salary progression. Achievement of professional standards. Professional and peer recognition.</th>
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<tr>
<th>Links to changes in practice</th>
<th>Links between policy and practice often weak – optional</th>
<th>Strong – development must be demonstrated through performance assessment.</th>
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<tr>
<th>Role of teacher/ subject associations</th>
<th>Marginal, responsive role.</th>
<th>Central, initiating, orchestration role</th>
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<tr>
<th>Funding, who pays?</th>
<th>Employer responsibility</th>
<th>Primarily teacher responsibility</th>
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</thead>
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**KEYNOTE:** *What qualities does an excellent teacher of mathematics have?*

In 1999 Monash University and AAMT were successful in obtaining a 1999–2001 Strategic Partnerships in Industry Research and Training (SPIRT) Grant to proceed with the research project titled, *Research and Development of National Professional Standards for Excellence in Teaching*
Mathematics. Monash University is the institution undertaking the research; the teachers’ Association is the ‘industry partner’ (the outside body with a vital interest in the research).

Morony (1999) defined ‘professional standards’ as they apply to this study and has provided reasons for developing them:

In the current context in education in this country, professional standards are a statement of what teachers need to know and be able to do in order to do their work at an acceptable level. They go beyond mere statement of required initial qualifications, although these may be important. They can be standards for entry into the profession. Or they can be about accomplished or expert performance of the work of the profession, linked to monetary rewards. The reasons for having professional standards can range from building community confidence in teachers’ work and thereby improving the status of teachers and teaching to supervision of individual staff members by principals. Ensuring that students have appropriately skilled teachers is essential – public statements of standards can help in this. (p. 42).

Boston (1999) argued that the teaching profession should be prepared to participate in the construction, ownership, implementation and monitoring of such ‘professional standards’. In addition to providing a “picture” of the excellent teacher, Ingvarson (1998) argued that in identifying standards of excellence, teachers would be able to design their own professional development to attain them. Morony (1999) regarded this kind of arrangement of professional development to be an essential characteristic of true ‘professional practice’, quite distinct from approaches focusing on ‘implementation of new policies’.

Accepting that it is important for there to be adequately described standards for excellence in mathematics teaching, how then should these standards be determined, and how can they be assessed? How is the study operating?

The AAMT/Monash Study

The AAMT/Monash project has two main aims (see Bishop and Clarke, 1999):

1. to determine consensual views on national professional standards for excellence in teaching mathematics in Australian schools (the Standards), and
KEYNOTE: What qualities does an excellent teacher of mathematics have?

2. to develop an assessment scheme and protocols for certifying this excellence.

However another important goal for the AAMT is to enable individual teachers to identify development goals within a framework that articulates ‘best practice’. Such guidance is important in the context of the implementation of ‘performance management’ and other enterprise arrangements in many Australian systems and schools.

Three fundamental principles form the basis for the project. The project will:

• base the National Standards for Excellence in Teaching Mathematics on the primacy of teachers’ knowledge of their work.
• take a research orientation by investigating and understanding best practice in articulating, disseminating, assessing and implementing the standards.
• complement systems’ and others’ work in defining and implementing teaching standards.

The specific objectives of the project are to:

• draw from and build on the international research and development base in the area of teacher professional standards and their assessment.
• establish structures which base the description of National Professional Standards for Excellence in Teaching Mathematics on the wisdom of the profession.
• consult widely in order to develop consensus statements of the Standards.
• document the Standards as a resource guide that informs career, professional and personal development of teachers of mathematics.
• identify examples of the Standards ‘in action’.
• develop assessment models for the Standards.
• establish the reliability of these assessment processes.
• establish a core of mathematics teachers (members of AAMT) able to conduct the assessment of their peers.
• enable the uptake of the Standards as part of the accreditation practices at system/employer levels.
• promote the Standards to the profession, systems and the wider community.
• provide a sustained income stream for the AAMT and its Affiliated Associations through sales of materials and services (consultancy, training and assessment) developed through the project.
A substantial research effort is thus required to develop a fully researched and operable national system of professional assessment, together with materials, training and Standards criteria that the AAMT and Monash see as necessary. In fact, the project aims to produce:

- a document describing the Standards required for a teacher to attain excellence in the teaching of mathematics, the content and form of which will have received widespread approval among both the mathematics teaching profession and employers.
- a set of exercises, activities and materials, appropriate for assessing excellence against the criteria described in the Standards document, together with protocols for their use.
- a trained group of teachers of mathematics in each State, who can reliably apply the assessment procedures and exercises.
- an evaluated training procedure for potential assessors.
- reports which document the whole research and development process, for circulation to representatives of AAMT, employer groups and education systems.
- papers and talks to national and international mathematics education conferences.
- a version of the final report to be published as a book.

To enable these outcomes to be realised, the research plan has envisaged 5 Stages taking place over 3 years:

Stage 1: development of draft Standards (1999).
Stage 5: trial implementation (2001).

As can be imagined, with such an ambitious collaborative project the organisation of the work is exceedingly complex. The structure of the project is as follows:

Management Team – Two representatives from AAMT and the two senior researchers from Monash University, who together manage the whole project on a day-to-day basis.

Steering Committee – giving overall professional guidance to the project, and consisting of one teacher per State/Territory (normally an AAMT Councillor), the members of the Management Committee, together
with representatives from the education systems and other employers’ groups.

*Teacher Focus Groups (TFGs)* – key teacher working groups especially established for this project in four states: Victoria, South Australia, Tasmania and New South Wales.

*Project Team* – consisting of members of the Management Committee, other researchers at Monash and one representative from each of the TFGs.

*Reference Groups* – ad hoc groups in other States and Territories.

**Progress of the Project: Stage 1, Development of the Standards**

The first part of the draft Standards has been developed through the work of the TFGs. Officers of the state association affiliated with AAMT invited at least 20 active members of their associations to attend the first TFG meeting. Those invited were experienced and expert teachers of mathematics who would be willing to be involved in each of the five stages of the project. Approximately 15 attended from each of the four states involved. Each TFG met on two occasions during 1999 (or for about 14 hours) with members of the Project Team, and is continuing to meet in 2000.

There has been extensive reviewing of the literature on Professional Standards, not in order to copy what exists elsewhere, because the Australian teaching situation and context has unique features. The aim has been to draw on what is known so far about practice in establishing and developing standards of excellence in teaching (Bunday & Kelly, 1996; National Board for Professional Teaching Standards, 1989; Ingvarson, 1998).

The Steering Committee has also had input into the deliberations concerning the shaping of the draft structure, and what has emerged is a structure that truly represents the teachers’ consensual views. At this stage the structure is referred to as Draft Descriptors, as they form only one part of the Standards development process.

The Descriptors’ structure consists of three Domains:

<table>
<thead>
<tr>
<th>Domain 1: Professional knowledge</th>
<th>Domain 2: Professional attributes</th>
<th>Domain 3: Professional practice</th>
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<tbody>
<tr>
<td>• Knowledge…of students</td>
<td>• Personal attributes</td>
<td>• Learning environment</td>
</tr>
<tr>
<td>• Knowledge…of mathematics</td>
<td>• Personal professional attributes</td>
<td>• Planning for learning</td>
</tr>
<tr>
<td>• Knowledge…of students’</td>
<td>• Community responsibilities</td>
<td>• Teaching in action</td>
</tr>
<tr>
<td>learning of mathematics</td>
<td></td>
<td>• Assessment</td>
</tr>
</tbody>
</table>

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Each of these Descriptors is described in a paragraph such as the one below for the *learning environment* which occurs in Domain 3:

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Excellent teachers of mathematics establish an environment where the norms and values maximise students’ learning opportunities. The psychological, emotional and physical needs of students are addressed and the teacher is aware of, and responds to the diversity of students’ individual needs and talents. Students are empowered to become independent learners who are motivated to improve their understanding of mathematics and develop enthusiasm for, enjoyment of, and interest in mathematics. In an inclusive and caring atmosphere of trust and belonging, active engagement with mathematics is valued, communication skills are fostered, and co-operative and collaborative efforts are encouraged.
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**Progress of the Project: Stage 2, Verification of the Written Descriptors**

In this phase of the research we have been concerned with questions such as “What do teachers of mathematics understand by the Standards descriptors?” “Where are the significant misinterpretations?” etc. This phase involves two processes, firstly the circulation of the draft Standards to the whole membership of AAMT for comment. At the time of writing this paper the questionnaires have not yet been fully analysed, but there is clearly a great deal of support for the structure and for the individual statements in it.

The second part of the verification process involves the teachers in the TFGs in the collection and development of practice exemplars of the Descriptors. This stage is not just necessary for good exemplification but it starts to focus more attention on the assessment and evaluation of teachers’ practice in terms of the Descriptors.

**General Information Dissemination and the Next Stages**

The project has now received widespread publicity both within the mathematics teachers’ community and in the wider educational environment. Articles have appeared in the teachers’ journal, The Australian Mathematics
Teacher (Morony, 1999), papers have been presented at both state and national professional and research conferences (see Bishop, Clarke, & Siemon, 1999) and professional development sessions. On the wider stage, there has been an influential forum in Melbourne organised in part by the Australian College of Education. The topic of the Forum was *Professional Teaching Standards: Issues, Challenges and Opportunities*. There are two similar SPIRT projects being undertaken concurrently by the Australian Science Teachers Association (ASTA) and jointly by the Australian Literacy Education Association (ALEA) together with the Australian Association for the Teaching of English (AATE). Various newspaper reports have appeared and the projects are certainly getting publicity.

This is important because of the next stage of the project, which concerns the Validation of the Standards. As a result of the feedback from the AAMT members, the TFGs and the Steering Committee, the Interim Standards document will be developed which will include Descriptors and Exemplars. It is crucial that the various influential groups involved in this stage are as informed as possible about the ideas developing in the project.

The validation stage involves two distinct research questions and therefore two distinct processes. The first question is: “How valid are the Interim Standards in relation to classroom and school activities and practices?” This we refer to as the *internal validation* question. The second question is: “Do the Interim Standards represent excellence in mathematics teaching, in the eyes of the employer groups and educational systems?” This is the *external validation* question.

Researching the internal validation question will take place in schools and classrooms, documenting the practices and collecting evidence from volunteer teachers in relation to the Standards. These teachers will work closely with the TFGs during this phase. There will inevitably be related issues of context and generalisability, and about the role of the school structures and support mechanisms. One of the assumptions to be tested in the research is that excellent teachers of mathematics should be able to be identified irrespective of the particular contexts in which they are currently teaching.

The research related to external validation will require comprehensive interview work with the representatives of the educational systems and employer groups. This part of the process will yield practical evidence of the developing competency frameworks and level criteria, as well as examples of certification processes and protocols. The result of this stage will be a...
revised set of Interim Standards, which will be used as the basis for the work of the final stages of the project.

Final Comments
In general the project is on track to deliver the outcomes described above, although there have been some inevitable bureaucratic delays. The project team has however been heartened by the enthusiastic way the project has been received and supported by the TFGs and the other teacher groups. There is no doubt in our minds that teachers welcome this kind of support and recognition of their activities, and their enthusiasm has shown itself in the dedicated ways they have participated voluntarily in the various aspects of the project’s work.

Challenges still remain, particularly we anticipate in the Validation stage, where we shall attempt to gain both internal and external agreement about precisely what constitutes excellent practice in the three domains. On the more political front, there are many issues to be faced concerning the States’ policies and actual practices of rewarding teachers assessed to be excellent on the Standards. The Management team will be working closely with systems’ representatives in the Validation stage to ensure that their concerns are taken into consideration. Keeping the “control” of the process within the mathematics teaching profession will be the main challenge, while acknowledging that the systems are likely to provide the incentive for most teachers to ultimately participate.

In part we are reassured by the feedback from various influential groups who recognise the need for a system of professional recognition amongst teachers, but who don’t wish that to be solely associated with administrative responsibilities that take excellent teachers away from the classroom. The strength of this particular project and initiative is that it is focussed on recognising and rewarding excellence in the teaching of mathematics.

References
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