Commentary on The Status and Quality of Teaching and Learning of Science in Australian Schools[1]

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This is a very thorough report and, in the absence of anything similar in regard to the teaching of mathematics, I will comment on each of the recommendations and their connections with mathematics teaching.

I am profoundly disappointed that, once again, the teaching of science has been isolated from the teaching of mathematics. Until young people have both a quality science and mathematics education, their scientific literacy must be of questionable quality and their career opportunities all too often severely limited. The Glenn Commission report[2] published in America at about the same time as this Australian report was completed addresses similar issues but in both mathematics and science.

It is clear that most, if not all, English-speaking, Western nations face major problems in the teaching of mathematics and science and that the major challenge is the supply of teachers. In Australia there is a greater problem with the supply of mathematics teachers than with science teachers, a situation I will discuss further below. In part this relates to the use of mathematical expertise outside of teaching and research, especially in the IT and financial services sectors.

It is also worth noting that access to advanced mathematics is now being viewed by some as a civil rights issue in the United States[3]. This is something seldom discussed in Australia although the recent book by Teese clearly equates mathematics achievement with socioeconomic factors[4].

Recommendations

The recommendations are introduced by a statement of premises. These include a statement that "the purpose of science education is to develop scientific literacy which is a high priority for all citizens…". There is no reference to career options or life chances associated with the study of science. Clearly mathematical and scientific literacy are important for informed citizenship but I think there are serious equity considerations if mathematics education is only perceived as related to citizenship.

I do not believe that mathematics education is just about 'citizenship'. Mellin-Olsen[5] argues this much more clearly than I can with his clear reasons for mathematics to be part

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[1] A research report prepared for the Department of Education, Training and Youth Affairs by D. Goodrum, Mark Hackling and Leonie Rennie, August 2000 (published 2001)

[2] Glenn, J. (Chair) (2000). *Before It's Too Late: A report to the Nation from The National Commission on Mathematics and Science Teaching for the 21st Century*.
(see www.ed.gov/americacounts/glenn)

[3] This relates to the publishing of `Radical Equations: Math Literacy and Civil Rights' by Robert P. Moses and Charles E. Cobb Jr. Moses

[4] Teese, R. (2000). *Academic success & social power.*

[5] Mellin-Olsen, S. (1987). *The Politics of Mathematics Education.*

of a young person's toolkit for dealing with life's challenges. It fits nicely with the view of the National Committee for Mathematics that the mathematical sciences are a generic, enabling technology[6]. I firmly believe that, in regard to mathematics, not only must it be well taught but students must make reasoned choices when they choose not to continue studying it. At the moment it is neither well taught, nor do they make reasoned choices about studying it and at what level. This probably applies to the majority of students.

My comments on the recommendations should be viewed in the light of the above.

Recommendation 1—Awareness

This recommendation is very vague as it is directed at "…the importance of sciences education in schools, particularly its fundamental role in developing scientific literacy". One of the suggested actions is about 'making science more tangible and relevant, particularly to secondary school students'. This gets to something more concrete and certainly connects with what the Australian Mathematical Society (AustMS) wants to see happen for mathematics. Contemporary applications of mathematics and the 'mathematisation'[7] of many careers is largely missing from the information many students are receiving. A recent story in *The Age* in Melbourne quoted a year 12 student who was studying biology, physics and the lowest level mathematics. With the dropping of pre-requisites for many university courses, he may even end up in a science-based course next year but it would be nice to know that he knew the implications of not having a stronger mathematics background.

Science teachers have a wealth of awareness materials they can draw on. Zoos, museums, marine centres, CSIRO etc—many with science teachers attached. Most of the Science and Technology Awareness Program money has gone to science. I have no argument with this but there is a lack of balance and if students can't see the relevance of mathematics, then eventually many turn from science when they find they do not have enough mathematics to go as far as they want to. This does not just affect science students—I sat next to a young woman from Treasury on a plane recently and she was very bitter about the career advice she got in regard to the mathematics needed to do well in an economics degree.

The bottom line about 'awareness' is that parents and students want to know about the careers associated with science and mathematics. Some www site development in a number of states (WA and Victoria for e.g.) are starting to move in this direction.

Part of this has to be awareness that doing mathematics improves your chances of flexible career paths and being a better scientist, engineer, financial planner etc. There is a need to be very wary of further 'science' awareness that does not address an awareness of 'mathematics' in science.

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[6] National Committee for Mathematics (1996). *Mathematical sciences: Adding to Australia.*

[7] A term now being used in the United States to underpin the essential role of mathematics in science, technology and innovation.

Recommendation 2—Teacher supply and demand

This is fairly low-key with suggested HECS exemptions and support for science professionals making a career change into science teaching and incentives for experienced teachers to stay in the classroom.

It is probably low-key because science does not face the crisis in supply of teachers that is already occurring in mathematics. The most recent figures I have seen for Victoria showed science methods enrolments about double those in mathematics. Teaching out of field is a much smaller problem in science than in mathematics[8].

Because of the salaries and career options mathematics graduates have, and the demand for mathematicians world-wide, there is only one option to meet demand for mathematics teachers and that is to retrain those teaching out of field. I cannot see how this can be done without the Commonwealth funding the necessary places and the States funding the study leave. Similar actions may also be necessary to up-grade physics and chemistry teachers for the senior years.

Recommendation 3—Teacher Education

This relates, in particular, to the staff profile in teacher education. Again the lack of data in Australia becomes a problem. A recent study in the United States suggested that about 50% of their mathematics educators reach retirement age in the next two years and there are few replacements in the pipeline[9]. Further, increasingly mathematics and science educators are tied up with writing the kind of report that I am commenting on, or managing projects that would have once been done in curriculum sections of the state and federal bureaucracies.

Schools of education need more funding and they need more staff. Contact hours in teacher education have been reduced and this impacts on the quality of exiting students, especially in content areas such as mathematics and science. There are insufficient places, particularly at the graduate diploma level. I suspect that, in Victoria, a cohort of mathematics and science teachers could be found for a mid-year intake if the places were made available. I am far less sure of the quality of the course they would be offered as I'm not sure that any university has the capacity to teach it and could find appropriate staff[10]. I know of one big school of mathematics where there is increased student load but no available staff (there is money for additional staff) can be found so everyone, from the Head of School down, is taking an extra tutorial. It is not just secondary schools that have staffing problems.

I don't think this section deals with a possibly very big problem about lack of doctorates in mathematics and science education and the probable need for specific incentives in this area. It may only be a problem in mathematics. Why would anyone do a masters or above in the discipline plus teacher education plus a PhD in mathematics

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[8] For further discussion on this see Thomas, J. (2000). *Mathematical Sciences in Australia: Looking for a Future* (pdf format available at www.FASTS.org).

[9] Reys, R. (2000). Doctorates in mathematics education—An acute shortage. *Notices of the American Mathematical Society, 47*(10), 1267-1270.

[10] I'd actually oppose this on educational grounds. I believe in separate methods but believe beginning teachers should interact with others from across disciplines in their core subjects.

education—the kind of background many who will leave the universities in the near future have—without some real incentives to do so?

And this whole area can't be isolated from the fact that the university system is becoming dysfunctional.

Recommendation 4—Teacher professional development

This is also bland and motherhood. I think it is accepted that teacher should have PD and the reduction in PD funding from all sources is a national disgrace. No other employer of a graduate workforce would spend so little on keeping that workforce up-to-date as happens in education. There is also no mention of PD in the discipline areas and if mathematics and science teachers are going to enthuse students they must have some knowledge of new developments in their fields.

Recommendation 5—Teacher professional standards

I particularly support certification provided it is as mathematics and science teachers. The lack of this is one of the reasons both State and Federal governments can ignore teacher shortfalls and teachers teaching out of field. Frankly I think ASTA and AAMT should have done this on a voluntary basis for their members years ago and the well qualified teachers would probably already be reaping the rewards, e.g. incentives to stay at particular schools.

Recommendation 6—Resources

All recommendations are equally applicable to mathematics. In particular the focus on the compulsory years of secondary is particularly important in mathematics. This is where far too many students are taught by teachers teaching out of field, for insufficient time, using less than ideal textbooks, in too large a class, and with no support for students with difficulties.

In regard to time, it should be noted that quite small increases in the amount of time can produce a big demand for more teachers in a specific area across a State[11].

Recommendation 7—Assessment

Assessment must match curriculum so this follows 6. National monitoring by sampling, which is suggested for science, would be a huge improvement on what happens currently in mathematics. State and national whole cohort testing is an expensive waste of money which gives little useful information on where curriculum, student achievement or teacher PD should be targeted.

Recommendation 8—National collaboration

The main suggestion is for a National Council for Science Education which may be appropriate for science teaching. The problems with mathematics teaching are now so

[11] See Thomas, J. (2000). *Mathematical Sciences in Australia: Looking for a Future* (pdf format available at www.FASTS.org).

firmly linked with the problems in the discipline area in the universities that mathematics would be better served by a national collaborative effort that could be under a more generic National Council for the Mathematical Sciences. There are other possible mechanisms and some are alluded to in the report (Thomas, 2000) already referenced.

In regard to another suggestion, I am not at all sure that asking DETYA to monitor the demand and supply of teachers, and participation of students in upper secondary science courses, is sensible as I think this is something the States should be able to do with greater accuracy than DETYA. Both the State and Federal governments have appalling records in regard to this. The work of Dekkers, De Laeter and Malone has provided on-going data on year 11 and 12 participation and has been very useful. It could provide a useful platform for further work on participation. Any work on teacher supply must take account of teachers teaching our of field—the hidden shrotage.

Recommendation 9—Implementation of these recommendations

As there is no similar report in mathematics education this does not apply to mathematics.

Conclusion

As I skimmed this report, and reflected on the recommendations, it has reinforced my belief that science education in Australia has its problems but that it is profoundly better off than mathematics education.

There is better community awareness of the role science plays in our lives, there are still quite reasonable numbers of science teachers in the pipeline and some good curricula available. Meanwhile, the potential supply of mathematics teachers will be almost non-existent when the current influx of mature age people dwindles as it did in the UK. This, and the much larger number of teachers teaching out of field, present a huge challenge to mathematics education.

This is not to suggest the recommendations in regard to science education should not be implemented. However, students deserve a good mathematics education if they are to take full advantage of improved science education.

I repeat what I said at the beginning—it is a real pity that this report did not look at both areas together. And the last thing mathematics education needs is for a similar report be started now, thereby delaying action for another couple of years.