

# AMSI Occasional Paper 2

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## **AUSTRALIAN SECONDARY MATHEMATICS TEACHER SHORTFALLS: A Deepening Crisis**

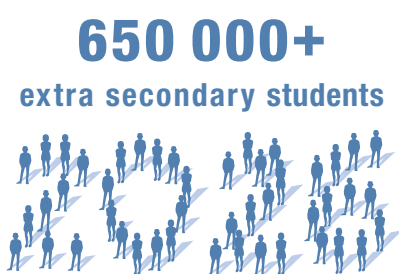
# Australian Secondary Mathematics Teacher Shortfalls: A Deepening Crisis

*...the Panel wishes to note the further development needs of a group of teachers that is somewhat unique to mathematics (and science), that is teachers who are currently teaching mathematics in secondary schools, but who have not been fully qualified in mathematics or mathematics education.*

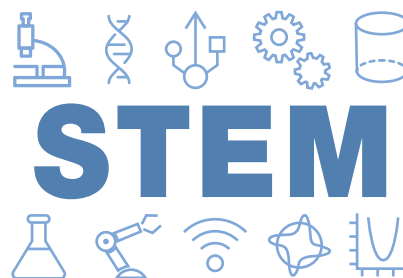
Discipline Review of Teacher Education in Mathematics and Science (1989)<sup>1</sup>

As evidenced from the 1989 quote, Australia has had a problem with mathematics teacher supply for a long time. It is evidenced in the number of teachers reported as teaching out-of-field<sup>2</sup> and the difficulties schools report in filling vacancies.<sup>3</sup> Secondary schools are now experiencing a large increase in enrolments that will exacerbate the situation. This paper examines how the shortfall arose. More importantly, if Australian students are to have the great teachers they deserve, what can Australia do to attract more mathematics teachers and retrain existing teachers?

## Key points



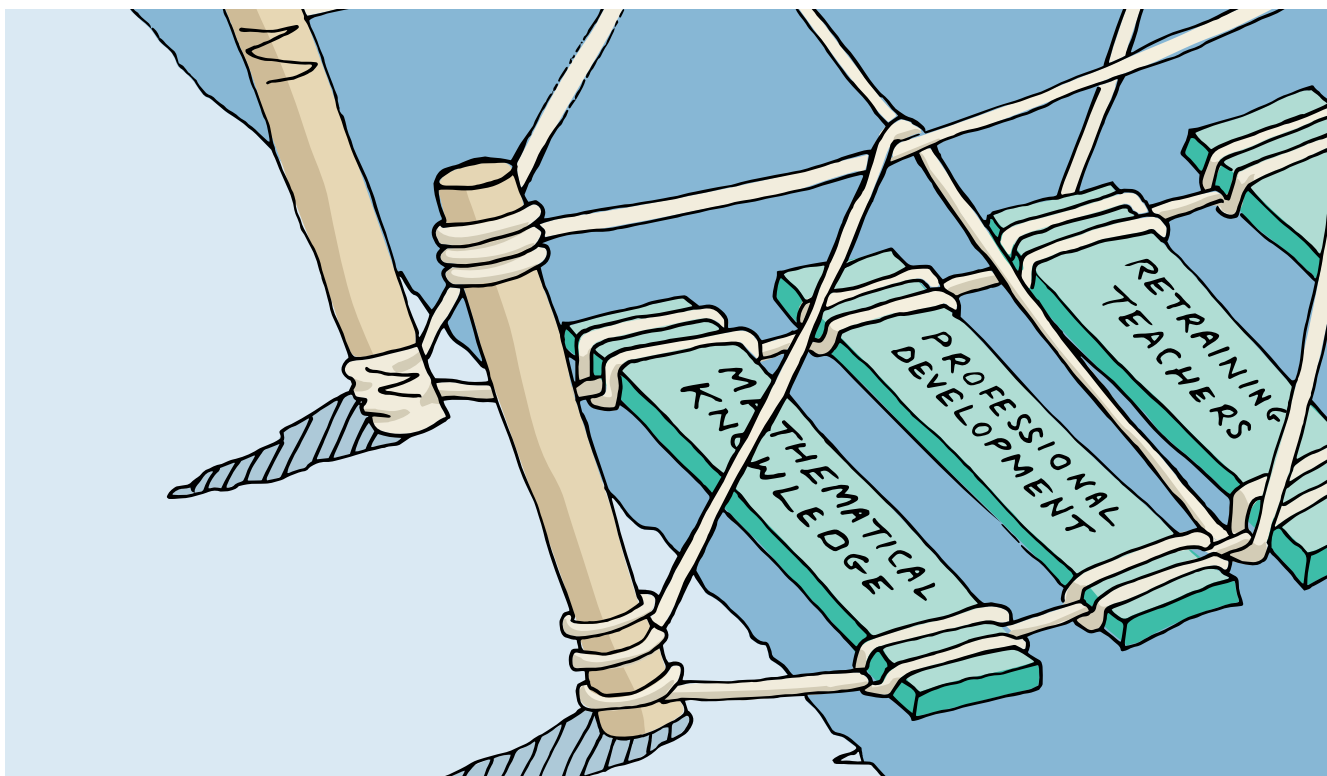
The problem with the undersupply of post-primary mathematics teachers began in the late 1980s and has grown slowly worse. The extent of the problem is illustrated by the estimated amount of out-of-field teaching occurring with less than one in four students having a qualified mathematics teacher in each of Years 7 to 10.<sup>4</sup> **The situation is about to worsen with a projected annual increase of 650 000 new students.**



The shortfalls in mathematics teacher supply that emerged in the 1980s were precipitated by increased enrolments in secondary schools and programs that encouraged the participation of girls in mathematics. In 2019 secondary schools are again facing increased enrolments. There are also many programs in place to encourage more students, especially girls, to continue with mathematics.



The current difficulties with out-of-field teaching, and meeting the needs of increased enrolments, is compounded by Australia not having prepared enough mathematics teachers for years. This can be turned around but will need a long-term commitment to attracting more mathematics teachers and retraining existing teachers.



## MATHEMATICS TEACHER SHORTFALLS: HISTORICAL BACKGROUND

A Survey of Mathematics Programs and Resources was conducted in Victorian State Secondary Schools in 1981–82.<sup>5</sup> All schools were sent the survey and 92 per cent responded. It can be inferred that its findings were reflective of the national situation. The results for the qualifications of mathematics staff are shown below.

### Secondary school teachers - tertiary study in the discipline

		YEARS OF STUDY					Total
		>3	3	2	1	0	
METHOD	Double	4	20	2	0	0	26%
	Single	2	22	20	7	1	52%
	Nil	0	1	4	9	6	20%
	Primary	0	0	0	1	2	3%
		6%	43%	26%	17%	9%	

**Note:** Method is the subject that examines the teaching of mathematics

At that time, for those with only a year of tertiary mathematics study, the most commonly held qualification was statistics as part of a Commerce or Psychology degree. The data suggests that schools had some out-of-field teachers but they were probably in schools that had a cohort of highly qualified teachers to provide support and leadership. This quite healthy situation did not last.

In 1987 the *Report of the Working Group investigating the Quality and Quantity of Mathematics and Science Teachers* was published.<sup>6</sup> It found:

- That the shortage of mathematics teachers was hidden. It found long term vacancies were being absorbed with the use of out-of-field teachers for junior classes
- Shortages were also being absorbed with a decrease in the amount of time devoted to mathematics. For example, 58 per cent of Year 7 mathematics classes were of 240 minutes or more in 1981–82 but in 1987 this had declined to an average of less than 200 minutes

The Victorian findings are reflected in a Queensland study.<sup>7</sup>

The shortfalls were ongoing. In 2006 the Australian Council of Deans of Science examined the demand for qualified mathematics teachers in secondary schools.<sup>8</sup> It is likely that the teacher responses were skewed towards those who saw themselves as primarily teachers of mathematics and that out-of-field teachers were underrepresented. Nevertheless, 8 per cent of the teachers had studied no mathematics and 20 per cent had no mathematics beyond first year. Many teachers had not studied a mathematics teaching method, including one-third who only taught junior and middle school. Further, three in four schools reported difficulties recruiting suitably qualified teachers with schools in more remote regions reporting the most difficulty.



The serious shortfall in the supply of secondary mathematics teachers that emerged post the 1981–82 survey can be attributed to an increase in student numbers. Between 1980 and 1993 Year 12 retention increased from 35 per cent to 77 per cent.<sup>9</sup> Further, national and state programs to address the under-representation of girls increased their participation in mathematics. For example, the evaluation of the “Maths Multiplies Your Choices” campaign in Victoria found the choice of subjects for Year 10 girls shifted from 43 per cent choosing maths/science to 63 per cent. Some of the negative feedback for this project came from schools trying to cope with increased enrolments in mathematics, physics and chemistry.<sup>10</sup>

The *Victorian Working Group* study highlighted a rise in teacher cessations due to retirement or resignations in the period 1984–1986 and that mathematics and science teachers were resigning in greater numbers than other subject areas.<sup>11</sup> The Deans of Science found that fewer than half the mathematics teachers were confident they would be teaching in five years’ time. Further, of 452 teachers committed to leaving teaching within five years, the majority were experienced teachers. The younger teachers replacing them tended to have less tertiary mathematics studies.<sup>12</sup>

The numbers relating to secondary mathematics teacher graduates are of particular concern. Based on 200 minutes of mathematics instruction a week, the amount of time in the school curriculum devoted to mathematics is about 13 per cent for Years 7–10. It can be higher when Year 11 and 12 classes are taken into consideration. This implies that the percentage of new graduate secondary mathematics teachers should approach this figure. The 1987 report found that mathematics teacher graduates fell between 1984 and 1987. It appears the fall continued as 2001 data found the rate was 7 per cent across Australia.<sup>13</sup> From the most recent data available from some states, in Victoria it is now about 5 per cent<sup>14</sup> and in NSW about 7 per cent.<sup>15</sup>

## PERSISTING TODAY

### In 2019 schools again face a large increase in

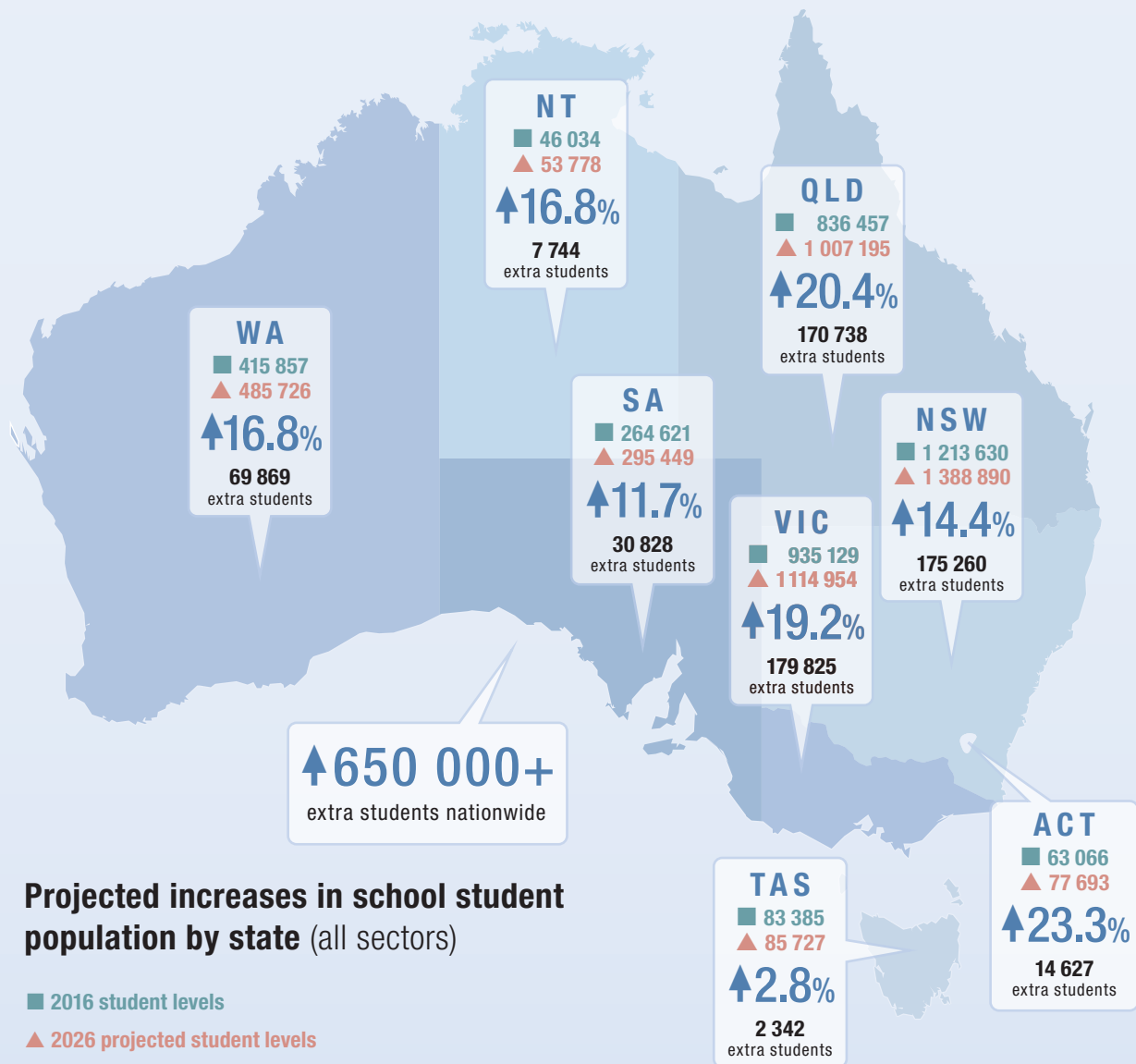
**enrolments.** In Victoria the Grattan Institute estimates an extra 10,900 students per year between 2018 and 2024<sup>16</sup>, but all states face big increases as a surge in primary school enrolments flows into secondary schools, with a projected 650,000 extra students by 2026.

So not only do schools face the need for more mathematics teachers, but Australia has not been producing enough mathematics teachers for years. Becoming a mathematics teacher has typically followed a path from Year 12 mathematics to a degree in mathematics, followed by a one-year DipEd or a four-year concurrent course offered by the Colleges of Advanced Education and some universities. The supply of new mathematics teachers is therefore related to Year 12 mathematics enrolments.

Ongoing data analysis of Year 12 mathematics enrolments showed that the proportion of Year 12 students taking advanced level mathematics in 2014 was 32 per cent lower than in 1996<sup>17</sup> and it has continued to decline.<sup>18</sup> Additionally, mathematics in Australian universities suffered a major decline post 1996.<sup>19</sup> A number still do not offer a major in mathematical sciences.<sup>20</sup> Some of these institutions have large numbers of education students. There are limited opportunities to study mathematics outside of the major capital cities and none in one of the territories. In 2003, only 0.4 per cent of Australian university students graduated with mathematics or statistics qualifications, compared with the Organisation for Economic Cooperation and Development (OECD) average of 1 per cent.<sup>21</sup> This figure was unchanged in 2014.<sup>22</sup>

A thirty-year decline in the supply of secondary mathematics teachers will not be solved overnight. Actions are needed now to improve the number of students participating in the advanced Year 12 mathematics courses. That will translate into more mathematics graduates and more mathematics teachers. So the challenge is to improve what is happening now, in schools, and that means tackling the out-of-field teacher issue.

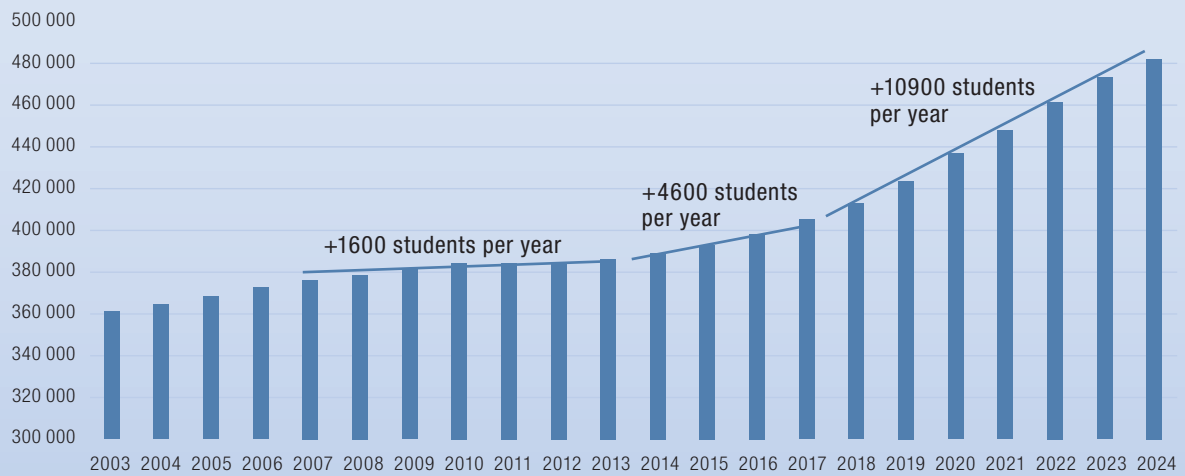




### Projected increases in school student population by state (all sectors)

■ 2016 student levels  
▲ 2026 projected student levels

### Estimated secondary school students in Victoria (all sectors)

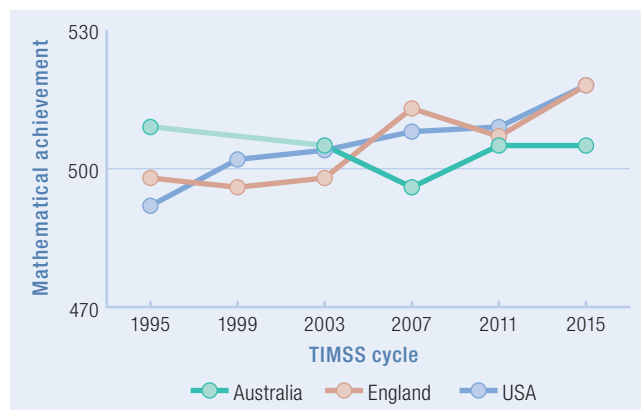


Graphs courtesy of Peter Goss, School Education Program Director, Grattan Institute

# THE MATHEMATICS IN MATHEMATICS TEACHER EDUCATION

**Teachers' knowledge and skills are paramount in students' success.** Here we explore what is known about the knowledge and skills of Australian mathematics teachers, and what can be done both to assist existing out-of-field teachers and to attract more new teachers.

England and the USA are English speaking countries with many of the same demographics, similar curricula and teacher preparation. All three countries have a problem with an adequate supply of mathematics teachers. In the 1990s Australian Year 8 students' TIMSS results were higher than both England and the USA in statistically significant terms. Australian results declined from the mid-1990s and both England and the USA improved to be above Australia in statistically significant terms.<sup>23,24</sup> The following outlines some possible solutions by drawing on actions in England and the USA that may explain international improvements and reports on an Irish program that has had a significant effect on out-of-field mathematics teaching.



The lack of knowledge or guidelines concerning the mathematics in mathematics teacher education in Australia becomes apparent when examining:

- available data concerning mathematics teachers,
- teachers' mathematical knowledge,
- attraction of new teachers, and
- retraining of existing teachers

Australia needs much more explicit guidelines concerning the mathematical content knowledge needed for mathematics teachers of Years 7–10 and Years 11–12.

## DATA CONCERNING MATHEMATICS TEACHERS

The mathematical future of Australian students cannot depend on finding a definitive answer to how many mathematically trained teachers Australia has. As identified in AMSI's Occasional Paper 1, *Crunching the numbers on out-of-field teaching in maths*<sup>25</sup> and the AMSI *Discipline Profile*<sup>26</sup>, there is a serious problem and it will continue to worsen unless

it is addressed. The AMSI findings are supported by the most recent TIMSS data that found 22 per cent of Australian Year 8 students were taught by out-of-field teachers, compared to an international average of 13 per cent.<sup>27</sup>

The difficulty of obtaining discipline specific data is shown by, for example, Weldon.<sup>28</sup> He noted that:

*The registration process for teachers requires a recognised qualification but does not endorse a registrant for a given level or subject. That is, a registered teacher is a registered teacher, not a registered primary teacher or a registered secondary teacher specialising in history and economics, or a registered teacher (F-10) or a registered teacher (middle years). From a data perspective this represents an enormous gap in our understanding of the teacher workforce (p.14).*

The rise in secondary enrolments from 2018 is noted but:

*A lot more is known about the current teacher workforce and the likely demand for teachers than is known about the pool of teachers available to work or the likely future supply of teachers (p.10).*

The 1987 Victorian Working Group argued for the adoption of a coordinated policy for labour force planning.<sup>29</sup> Much later a review of teaching and teacher education stated: "...teacher workforce planning across Australia does not match the complexities of, and requirements for, the contemporary profession and is frustrated by the inadequacy of available data."<sup>30</sup>

Australia's education ministers are implementing the *Australian Teacher Workforce Data* collection.<sup>31</sup> However, the accuracy of this data will be dependent on the quality of data held by the state and federal governments and on teachers' participation. There are clearly gaps in the data held by the States, especially as it relates to subject specialisation.

The Victorian government teacher supply and demand report notes that there are data limitations that have impacted the analysis. Subject specialisation is one identified gap.<sup>32</sup> An earlier report has more details and clearly identifies difficulties with mathematics teacher supply.<sup>33</sup> A NSW report has greater detail<sup>34</sup>, noting that secondary completion estimates grew in 2012 to 2014, with increases in almost all key learning areas.



The growth, however, has not aligned with the Department's needs. The report notes a decreasing supply of mathematics teachers affecting all areas of the State and is concerned that an increase in retirement rates above current projected levels and, to a lesser extent an increase in resignation rates, would have a substantial negative impact on the total net supply of mathematics teachers.

The lack of data on subject specialisation aligns with the lack of specification concerning the mathematical content knowledge of teachers. The current standards for teachers are generic.<sup>35</sup> The standards for accreditation of initial teacher education courses mentions only "Mathematics/ numeracy – discipline and discipline-specific curriculum and pedagogical studies, at least one quarter of a year EFTSL" for primary teachers.<sup>36</sup> By way of contrast, a major is defined as undergraduate programs equivalent to three-quarters of a year EFTSL. This is less than the usual definition of a major and would likely be considered insufficient for teaching Years 11–12. There is no mention of specific discipline studies.

The lack of any specific recommendations with regard to discipline content compounds attempts to define out-of-field teachers. There is no common definition of what constitutes a qualified teacher in a given subject, even though secondary teachers teach specific subjects rather than being generalists as is the case with primary teachers. A definition of in-field teachers as having studied second-year tertiary level and teaching methodology in the subject should be considered woefully inadequate for teaching Years 11 and 12.<sup>37</sup>

The Australian situation is at odds with the USA where teacher shortfalls, employment information, study opportunities and other information is available on a state by state basis.<sup>38</sup>

## TEACHERS' MATHEMATICAL KNOWLEDGE

The last detailed discussion of the mathematics discipline knowledge needed to teach at primary and secondary level in Australia was in the 1989 *Discipline Review of Teacher Education in Mathematics and Science*.<sup>39</sup> In 2006, the Deans of Science argued that the pattern of tertiary study, content knowledge and pedagogical skills, is the best proxy currently available for the preparedness of Australian teachers. In summarising the views of the Heads of Mathematics in secondary schools they noted that most:

- required senior school teachers to hold at least a major and many expected higher level study
- expected middle school teachers to have least second year mathematics
- expected junior school teachers to have some university mathematics
- deemed study of mathematics teaching methods essential

The report found that teachers with the highest levels of mathematics related tertiary study were the most satisfied with their tertiary preparation.<sup>40</sup>

It is taken as given that a well-prepared teacher requires both content and pedagogical knowledge and skills. Generic and pedagogical skills are well defined by the Australian Institute for Teaching and School Leadership. Subject discipline skills are not. Australia lacks the kind of detailed initial teacher education standards that have been developed in the USA.<sup>41</sup> The mathematical community in the USA has also been very involved in the mathematical development of teachers<sup>42</sup> and in broad collaborative efforts illustrated by, for example, the work of Roger Howe who has challenged and stimulated mathematicians and mathematics educators to work together to examine mathematics education more critically and in imaginative new ways.<sup>43</sup> Discipline specific Praxis tests are taken by many individuals entering the teaching profession as part of the certification process required by many states and professional licensing organisations.<sup>44</sup> The emphasis on mathematical content in the USA extends to doctoral degrees in mathematics education where candidates can be required to study more mathematics as a condition of entry.<sup>45</sup>

In 2010, Professor Dame Celia Hoyles presented to the Australian mathematical community concerning successful strategies in England that were improving participation in mathematics and noted there was an "unerring focus on mathematics".<sup>46</sup> The strategies to encourage more students to continue with mathematics were similar to many being used in the AMSI Schools program<sup>47</sup> and nationally. Since 2002 the number of students taking A level Further Mathematics, which is similar to an Australian advanced course, has more than doubled from 44,000 to 90,000.<sup>48</sup>

*A concerted effort by government and the profession can turn a downturn into a massive uptick.*

Dr Tony Gardiner, former Education Secretary of the London Mathematical Society<sup>49</sup>

In England and the USA, there has been collaboration across discipline and education professionals. Australia needs a collaborative effort to develop a framework of discipline studies and pedagogical studies for mathematics teachers to inform the preparation of new teachers and the retraining of existing teachers. The depth of the teacher supply problem is such that courses need to be identified and accredited for teachers of Years 7–10 and for Years 11–12. There should also be encouragement for teachers to progress to the senior level. Before being amalgamated with the universities, some Colleges of Advanced Education had a Years 7–10 teaching methods course that was a pre-requisite for the senior mathematics methods course.





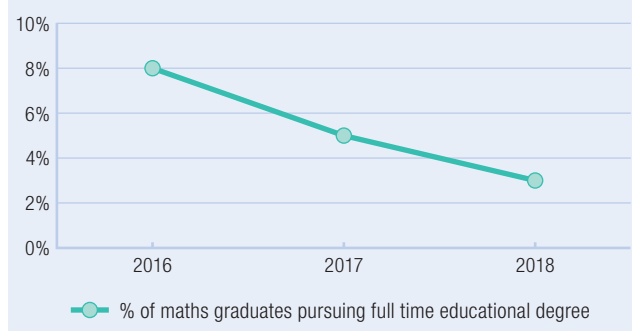
Australian teachers are well-trained in terms of the number of years of formal qualifications. However, both the USA and England have much better information about their teachers and accreditation and other mechanisms make the mathematics component expected much more explicit

### ATTRACTING NEW TEACHERS

The future supply of new teachers ultimately depends on improving Year 12 participation in the advanced level mathematics courses. Initiatives such as the AMSI delivered CHOOSEMATHS Project, funded from 2015 to 2019 by the BHP Foundation<sup>50</sup>, will assist with this. The expansion of pre-requisites for many degrees in the universities would improve the supply of graduates with sufficient mathematics to be effective teachers at the junior secondary level especially if it was made explicit the level of mathematics they needed to be teachers.

A more worrying issue is that the Deans of Science found in 2006 was that only 64 per cent of secondary schools were offering advanced level mathematics courses. Cumulative data relating to highest level mathematics courses for 2018 from Queensland, NSW and Victoria show this to be about 62 per cent.<sup>51</sup> There appears to be no data as to why schools don't offer the most advanced course. There are likely to be a number of factors including insufficient students to justify a class and not being able to find a teacher. In England centres were established to cater for students whose school couldn't offer the advanced courses on their own.<sup>52,53</sup>

A recent initiative may be a disincentive for mathematics graduates and career change professionals to become teachers. In 2011, a new national standard for accreditation of initial teacher education programs was endorsed by the Ministerial Council for Education, Early Childhood and Youth Affairs, requiring postgraduate courses to be of two-years duration. Its impact is not known but is likely to have been negative in attracting mathematics graduates, especially those with more than a three-year undergraduate degree, career change professionals and immigrant teachers. It needs to be evaluated as one limited study has indicated that the percentage of mathematics graduates going into full-time education appears to have fallen more than 50 per cent in the period 2016–2018.<sup>54</sup> The mathematical community argued at the time that the one-year diploma course should be retained and any second year completed over time. The second year could include further studies in mathematics.



Immigrant teachers face a qualifications-based assessment where work experience undertaken before or after the completion of an initial teacher education qualification is not taken into account.<sup>55</sup> Few teachers from countries where teachers have been sourced in the past would meet the two-year requirement.

Currently, only the NSW Department of Education has a comprehensive set of programs to address teacher supply in areas of shortfall.<sup>56</sup> There appears to be little publicly available from the other states. The NSW programs include opportunities to study more mathematics and various other scholarships and incentives, tied to permanent positions in NSW schools. Significant financial incentives are available to teachers prepared to teach in remote areas.<sup>57</sup> In particular, the NSW cadetships and internships where trainee teachers are employed as paraprofessionals while completing their training could be a mechanism for supporting career change professionals.

The NSW programs have some similarity to those offered in England. England also has support for acquiring the discipline knowledge<sup>58</sup> so that potential mathematics teachers can then access the generous support bursaries available.<sup>59</sup> The incentives available have recently been adjusted to include both payments during training and tax free payments in their third and fifth year of teaching as part of new retention strategies.<sup>60</sup>

### RETRAINING

Australia cannot attract new mathematics teachers in the numbers required. Teachers already in schools could be retrained to address the shortfall. **AMSI's submission to the parliamentary enquiry into the status of the teaching profession includes specific recommendations concerning how this could be done.**<sup>61</sup> Ireland provides an example demonstrating that retraining can be very successful.<sup>62</sup> In Ireland a national survey of 324 mathematics teachers in 51 secondary schools carried out in 2009 found that 48 per cent of the teachers did not have sufficient mathematics teaching qualifications for registration as a qualified mathematics teacher.<sup>63</sup> Ireland's Professional Diploma in Mathematics for Teaching resulted in a reduction in out-of-field teaching to 25 per cent.





The program consists of:

YEAR 1	YEAR 2
Calculus 1	Statistics
Calculus 2	Geometry
Algebra 1	History of Mathematics
Algebra 2	Calculus 3
Probability	Mathematical Modelling
3 Pedagogy Workshops (Calculus, Algebra & Number, Probability)	2 Pedagogy Workshops (Statistics, Geometry & Trigonometry)
Summer School	

Designed to meet Teaching Council requirements for registration as qualified mathematics teacher<sup>64</sup>, the program was delivered by the University of Limerick and the National University of Ireland, Galway, leading a national consortium of 13 higher education institutions. The intensive program makes significant demands on teacher time.

In Australia it would not be difficult for a group of mathematics teachers familiar with the Year 7–12 curriculum and university mathematical scientists to formulate discipline courses appropriate for teaching Years 7–10 and 11–12. Not only would this assist with retraining by providing existing teachers with appropriate courses to upgrade their skills, it would encourage undergraduates considering teaching to choose appropriate courses. It could underpin a collaborative approach to aspirational, not minimal, standards for initial teacher education and ongoing professional learning from all universities offering teacher credentials. Credentials for formal courses undertaken could build to certificate, diploma and post-graduate degrees.

Delivery would need to be very carefully considered. The school year in both the USA and Europe has a long break that is not interrupted by Christmas and the New Year. It is possible to provide intensive courses and workshops over several weeks and still leave teachers with time for a family vacation. Coordinated provision of courses for teachers in Australia needs to be flexible and delivered in ways that are informed by teachers.

Any retraining program should be able to be completed over time, it should not be compulsory and it should be free. Incentives such as financial rewards on completion of significant study, special leave, reduced teaching hours or other support should be considered. In particular, such courses could attract parents on family leave, or taking time out of the workforce to care for young children or ageing parents, and add to the supply of new mathematics teachers.

With appropriate government support the mathematical community—teachers, mathematics educators, mathematicians and statisticians—will collaborate to deliver appropriate courses and well-prepared teachers.

## FINAL COMMENTS

Developed over 30 years, the problem with Australia's mathematics teacher supply cannot be solved with anything other than a bipartisan generational commitment over a similar time span. Australia has excellent and innovative materials for the teaching of mathematics and a national curriculum that was developed with genuine involvement of education and discipline specialists. The issue now is summed up by the following:

*Personally, I believe the number one priority in math education right now is “house-cleaning”: let us take a deep breath and look at what we have done wrong—not having provided teachers with the foundational knowledge they need to carry out their basic duties of teaching—and go on from there.*

Professor Emeritus Hung-Hsi Wu, University of California, Berkeley<sup>65</sup>

Australia is failing to provide enough teachers with the mathematical content knowledge they need to teach the classes they are being assigned. Long term funding for the development, dissemination and maintenance of a viable infrastructure for delivery of mathematics courses and associated pedagogy is urgent.

Mathematics for primary teachers has not been discussed and clearly has impact for secondary schools. The mathematics education a primary teacher is a topic for another day. And initiatives to attract more mathematics teachers clearly have implications for other areas of shortfall.

## ACKNOWLEDGEMENTS

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**Dr Tony Gardiner**, former Education Secretary of the London Mathematical Society

**Professor Emeritus Hung-Hsi Wu**, University of California, Berkeley



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