Out-of-field teaching of secondary school mathematics in Australia

A Position Paper from the Actuaries Institute, the Australian Mathematical Sciences Institute, the Australian Mathematical Society, the Mathematics Education Research Group of Australasia and the Statistical Society of Australia

Executive summary

- Over **three-quarters of Australian year 7-10 students are estimated to have been taught by out-of-field teachers in mathematics**. Many Australian teachers are, of necessity, assigned to subjects outside their training, with mathematics the most affected. This obstructs student learning and affects teacher job satisfaction and retention. **This inequitable situation is severe in outer suburban, low SES, regional and remote schools where it reduces mathematics subject offerings and enrolments.** Fresh graduate teachers alone cannot defuse the crisis.

- We argue that **supporting out-of-field teachers to upgrade their knowledge of mathematics and mathematics teaching methods** is likely to be the most efficient and cost-effective approach to improving students' learning, particularly in economically disadvantaged schools.

- The need for change is critical for Australia's future, as functional **mathematical and statistical literacy underpins Australia's innovation, economic competitiveness and national security**. Without a guaranteed and growing graduate supply and a broadly numerate workforce, these fundamentals are at risk.

- Ensuring young Australians are taught by confident, knowledgeable mathematics teachers **empowers citizens to make reasoned decisions in the face of rapid changes** in technology use, media consumption, reliance on data and personal financial stability.

- **We advocate**
  - **a joint Commonwealth—State upskilling program** on a national scale for out-of-field teachers of mathematics, upgrading their knowledge of mathematics and mathematics teaching methods, supported by
  - **coordinated, comprehensive data collection on teacher specialisations** to create evidence-based targets and track progress.

- **We call upon State and Commonwealth Education ministers to immediately recognise the scale and impact of this problem**, and to adapt and adopt programs proven to be effective.

Contents:

Introduction

Australia is experiencing intense teacher workforce challenges that threaten the supply and equitable deployment of teachers across schools, subjects, and geographical regions. But in attempting to address these wide-ranging workforce challenges, we risk overlooking a less visible but more persistent problem– the phenomenon of ***out-of-field teaching***, especially in secondary school ***mathematics***. This is a result of much longer-term staff shortages in this vital discipline.

This position paper defines the features and scope of the out-of-field mathematics teaching challenge, explains why it matters, proposes a solution and outlines costs, benefits, incentives, and barriers to implementation.

What's the problem?

Australia doesn't have nearly enough qualified teachers of secondary school mathematics

In Australia, initial teacher education (ITE) programs are required to demonstrate that new teacher graduates "know the content and how to teach it" (AITSL, 2017). However, this doesn't guarantee that every secondary school will be staffed by the right combination of subject specialists, that is, teachers who are qualified to teach the classes and subjects they are assigned. The phenomenon of ***out-of-field teaching*** involves teachers being assigned to teach subjects that don't match their training or education (Ingersoll, 1999).

Teachers who teach mathematics out-of-field are qualified to teach other subjects, but they typically lack sufficient knowledge of mathematical content and have little or no formal preparation in the teaching of mathematics. This means that large numbers of students are being taught by teachers who lack the necessary knowledge, skills, and confidence for teaching mathematics. ***A recent study calculated that more than three-quarters of Australian students (76%) are taught by an out-of-field teacher between Years 7 and 10***, when it is crucial to build strong mathematical foundations and positive mathematical dispositions (Prince & O'Connor, 2018).

It is difficult to get accurate data on the extent of out-of-field mathematics teaching, and so how best to distribute limited resources.

There are two primary reasons for the lack of accurate data. First, ***there is no nationally collected data on graduate teachers' subject specialisations***. When they graduate from an accredited ITE program and register with their State or Territory teacher regulatory authority, new teachers are not additionally certified to teach the subject(s) in which they are qualified – except in New South Wales, where teachers' subject specialisations are recorded. Moreover, the universities do not reliably report the number of graduating teachers of mathematics (or of any other teaching discipline). ***This makes it nearly impossible to quantify how many mathematics-qualified teachers we have in Australia.***

Second, ***there is no consistent way of defining and quantifying "out-of-field"*** teaching in terms of teachers' qualifications in both mathematics content and methods of teaching mathematics. Accreditation of Australian ITE programs requires prospective teachers to take six semester-long courses in university mathematics and two in mathematics pedagogy (AITSL, 2016). However, criteria used in teacher workforce surveys that estimate the extent of out-of-field teaching typically accept a much lower knowledge threshold. For example, in

the recent Australian Teacher Workforce Data Teacher Survey (AITSL, 2021), respondents were only asked "if they had completed *one semester* of subject-specific study in content *or* pedagogy" (p. 88, emphasis added). According to this methodology, survey responses showed that *mathematics was taught by out-of-field teachers 40% of the time*. 2020 data from AITSL (2023) indicates that 33% of those teaching mathematics were out-of-field (as opposed to the percentage of classes taught). In our view these figures significantly under-estimate the extent of the problem and, importantly, do not measure the percentage of mathematics classes taught by out of field teachers.

Why does it matter?

Well-prepared, well-supported teachers are the key to delivering equitable and high-quality mathematics education

Teachers matter because they are the key influence on student learning at the classroom and school level (UNESCO, 2015). *Mathematical knowledge for teaching* is a blend of "knowing the content" and "knowing how to teach it". Teachers who are less confident in teaching mathematics are more likely to use poor teaching methods and less likely to develop their students' interest and confidence in mathematics (Beswick & Fraser, 2019). International studies have shown that when teachers possess higher levels of *mathematical knowledge for teaching*, their students perform better on mathematics tests than students of less knowledgeable teachers (Baumert et al., 2010; Hill et al., 2005). For example, in the most recent (2019) TIMSS assessment, Australian Year 8 students taught by fully qualified mathematics teachers (i.e., those with majors in both mathematics and mathematics education in their teacher education program) scored significantly higher than students taught by out-of-field teachers with neither subject-matter knowledge nor pedagogical knowledge in mathematics (Thomson et al., 2021).
Van Overschelde (2022) explains this is because "teachers teaching out-of-field generally engage in less effective instructional practices (e.g., scaffolding, question asking, content elaboration, lower pedagogical content knowledge) and are less able to create classroom environments that are conducive to student learning and academic growth" (p. 52).

Specialist teachers of mathematics start developing their *mathematical knowledge for teaching* during their teacher education program, when they study both rigorous mathematics content and effective mathematics teaching strategies. Other teachers who are assigned to teach mathematics out-of-field have not had the same opportunity to develop the professional knowledge they need to teach mathematics effectively.

Students in disadvantaged schools are more likely to be taught by out-of-field teachers than students in affluent schools

Addressing out-of-field teaching of mathematics matters because students who experience out-of-field teaching demonstrate less academic growth and lower academic performance than students taught by fully qualified teachers. PISA results consistently show lower mathematical literacy achievement by 15-year-old students from lower socioeconomic backgrounds and those in regional or remote areas De Bortoli et al., 2023). TIMSS paints a picture of educational inequity in both mathematics achievement and access to fully qualified teachers of mathematics. The 2019 results showed that the average Year 8 mathematics score for more affluent schools was 558 points, compared to 474 points for more disadvantaged schools[1]. Some of this achievement gap is no doubt related to the

[1] According to the TIMSS 2019 Assessment Frameworks, "The TIMSS mathematics and science achievement scales were created with the first TIMSS assessment in 1995, separately for each subject and each grade. The scale units were established

mathematics teaching gap, since Year 8 students from more disadvantaged schools also had a significantly lower percentage of qualified teachers (31%) than students in more affluent schools (54%) (Thomson, 2021). Similarly, US research has also shown that students disadvantaged by socio-economic status, ethnicity, language background, or special education needs are significantly more likely to be taught by out-of-field teachers than their more advantaged peers (Van Overschelde & Piatt, 2020).

The Australian TIMSS results resonate with findings from a much larger study of 5 million Grade 7 and Grade 8 students in Texas, which found unequivocal evidence that students achieved significantly lower mathematics exam scores when they experienced out-of-field teaching compared with peers taught by mathematics-certified in-field teachers (Van Overschelde, 2022). This study also found that the negative relationship between teaching out-of-field and algebra test scores was three time larger than the negative relationship between economic disadvantage and those test scores. This means that ***supporting out-of-field teachers to upgrade their knowledge of mathematics and mathematics teaching methods is likely to be highly effective in improving students' learning, and cost-effective, particularly in schools in economically disadvantaged regions.***

Mathematics and statistics play a vital role in all aspects of modern life

Mathematics and statistics matter because they permeate all aspects of daily life. Learning mathematics develops problem-solving and critical thinking skills that can be transferred to other situations and a range of occupations. The advanced physical and mathematical sciences make a direct contribution to the Australian economy of about $145 billion per year (2015 $), amounting to 11% of total economic activity in areas such as finance, computing, mining, transport, telecommunications (Australian Academy of Science, 2015). Having insufficient numbers of qualified mathematics teachers limits schools' capacity to offer advanced mathematics subjects in the senior secondary years that lead to university qualifications in these fields, including school mathematics teaching. The impact is not limited to university qualifications, with endemic out of field teaching challenging the functional mathematical literacy of students undertaking VET qualifications or simply entering the workforce straight from school.

Mathematical and statistical capability also impacts individual life choices, since young people who leave school with poor achievement in fundamental mathematics are more likely than others to experience unemployment or low-paid work, poor physical and mental health, and low levels of civic participation (Bynner & Parsons, 2006).

What might a solution look like?

Recruitment and retention strategies to boost the teaching workforce are insufficient for reducing the extent of out-of-field teaching of mathematics

The National Teacher Workforce Action Plan (Department of Education, 2022) proposes addressing the current teacher shortage through recruitment and retention – that is, by encouraging more people into the teaching profession and then keeping them there. These strategies are worthwhile in the long term, but are insufficient to reduce out-of-field teaching

so that 100 points on the scale was equivalent to one standard deviation of the distribution of achievement across all of the countries that participated in TIMSS 1995, and the scale midpoint of 500 was located at the mean of this international achievement distribution. …All results from subsequent TIMSS assessments have been reported on the same scale metrics, making it possible to measure growth or decline in countries' achievement distributions from assessment to assessment." http://timssandpirls.bc.edu/timss2019/frameworks/framework-chapters/assessment-design/reporting-student-achievement/

of mathematics in the next 5-10 years. The need for a solution is already urgent and additional strategies are critical.

In their analysis of what a recruitment solution might look like, Prince and O'Connor (2018) found that, if recruitment of new graduates matched retirement of in-field and out-of-field teachers, it would take 13.5 years to reduce the incidence of out-of-field teaching of mathematics from 30% to 15%. And to reduce out-of-field teaching to 10% in the next ten years, we would need to recruit new teachers at 120% of the retirement rate per year. This is clearly not a feasible solution, particularly in the light of increasing demand from outside teaching for a static supply of mathematical sciences graduates (AMSI, 2020; O'Connor and Thomas, 2019).

The alternative is to additionally ***support and upskill those teachers who are already teaching mathematics out-of-field***. To achieve a "10% in ten years" solution, Prince and O'Connor (2018) estimated that over the 10 years, in addition to new recruits, around one third of the out of field workforce would require upskilling. This solution has the advantage of working with a ready-made supply of teachers who already teaching mathematics classes, rather than relying on an uncertain supply and retention of new teaching graduates.

Out-of-field teacher upskilling programs should take advantage of existing resources and recognise teachers' diverse professional development needs, including full certification as a specialist teacher of mathematics

We need to understand that ***out-of-field teachers of mathematics are not a homogeneous group*** – they have come to be teaching out-of-field via different pathways and they experience differing levels of comfort with this role (see for example Hobbs et al., 2020).

Factors contributing to out-of-field teaching may be short-term or long-term. This means that a solution to the out-of-field teaching problem needs to identify and cater to different segments of the out-of-field teaching workforce.

- ***Temporary OOF status:*** For teachers with a new or temporary assignment to teach a mathematics class out-of-field and no expectation or desire to re-specialise in mathematics.
  Action: Promote access to existing online professional development resources and networks to increase teachers' confidence and repertoire of mathematics teaching strategies..
  Delivery/sources: Online resources could include those offered by Education Services Australia (https://www.esa.edu.au/), industry bodies such as ATSE (https://www.atse.org.au/), and the Australian Association of Mathematics Teachers (https://aamt.edu.au/).
  Cost: Minimal to none

- ***Short-term OOF status:*** For teachers with a current mathematics teaching assignment, some prior experience in teaching mathematics out-of-field, and an expectation of, or interest in accepting, future out-of-field mathematics teaching assignments alongside their main in-field subject(s).
  Action: Provide targeted professional development short courses and microcredentialling courses to increase teachers' mathematical knowledge for teaching. These offerings should (1) aim to strengthen mathematical content knowledge and mathematics pedagogical content knowledge for teaching topics in junior secondary mathematics and (2) deliver a credential that gives credit towards a formal certification program. There may also be scope for offering topics in senior secondary mathematics for teachers already qualified and confident in teaching junior secondary mathematics.

Delivery/sources: Courses could be sourced or developed from existing offerings of mathematics teacher professional associations or taken as one-off semester-long components of upskilling programs delivered by universities (see below).
Cost: Low

- ***Long-term OOF status***: For teachers with a current mathematics teaching assignment, some prior experience in teaching mathematics out-of-field, and commitment to becoming a qualified teacher of mathematics at junior and senior secondary school levels.
  Action: Design and deliver a nationally consistent upskilling program leading to formal certification as a qualified teacher of secondary school mathematics.
  Delivery/sources: This would be a newly designed program offered by a national consortium of higher education institutions with expertise in mathematics and mathematics teacher education.
  Cost: Moderate

We set out the case for the last approach – a ***national upskilling program for out-of-field teachers of mathematics*** – because it will have the greatest impact on reducing the extent of out-of-field teaching of mathematics.

How do we know that a national upskilling program delivering formal certification will make a difference?

Successful case in Ireland

We know from the case of the Republic of Ireland that such a program can make a difference. In 2009, a national survey of secondary schools in Ireland found 48% of teachers of mathematics classes were teaching the subject out-of-field (Ní Ríordái & Hannigan, 2009). In response, the Department of Education provided €7 million for the design and implementation of a postgraduate program upgrading the qualifications of out-of-field teachers to the level of a fully qualified subject specialist in mathematics. The Professional Diploma in Mathematics for Teaching (PDMT), is delivered by a consortium led by the University of Limerick. Four cohorts of 1,068 teachers graduated from the program. The Department of Education has since committed over €1 million in additional funding to cater for three more cohorts, which will lead to a further 600 teachers obtaining mathematics teacher certification by 2025. The national survey of schools was repeated in 2018 and found that the incidence of out-of-field teaching of mathematics classes had already dropped from 48% to 25% - with the PDMT being the primary reason for this reduction.

Research on the impact of the PDMT for the participants has shown that upskilled teachers were developing self-efficacy beliefs and pedagogical practices akin to those of in-field mathematics teachers (Goos & Guerin, 2022), self-reported changes in their beliefs about mathematics and their mathematics teaching approaches (Lane & Ní Ríordáin, 2019; O'Meara & Faulkner, 2021), documented high levels of job satisfaction and affective commitment (Ní Ríordáin et al., 2022), and indicated a greater sense of belonging as a mathematics teacher, with validation for their practice provided by their newly acquired mathematics teacher certification (Quirke, 2022).

While the Irish context is not identical to Australia's, the long-term success of the PDMT demonstrates the feasibility of a high-quality national program for upskilling out-of-field teachers of mathematics.

Australian upskilling programs are uncoordinated and inadequate

A recent analysis of out-of-field secondary mathematics teacher upskilling initiatives in Australia, released with this position paper, was sponsored by our consortium (Barker, Goos & Coupland 2024). This study showed that while some States do have university-based upskilling programs planned or under way, their scale is completely insufficient. For example, the Victorian government offered 75 places in 2022 and NSW 40 in 2023. We believe that the actual requirements lie in the hundreds, but only a full census of registered teachers by the various registration boards will reveal realistic requirements. Furthermore, our analysis indicated that at a national level, there is no coordination of programs, course requirements or incentives, and there are inconsistencies in program costs, duration, and content.

A successful upskilling program must also incentivise teacher participation, for example, by reducing the barriers of time and cost commitment, ensuring teachers receive support from their school, certifying the additional qualification, and linking the qualification to career advancement. There is a clear need for Commonwealth, jurisdictional and university collaboration.

Recommendations and Call to Action

The need for change is critical. Ensuring Australians are taught by confident, knowledgeable mathematics teachers is required to secure Australia's innovation and economic security, as well as to prepare citizens to make reasoned decisions in the face of rapid changes in technology use, media consumption, data proclivity and personal financial stability.
Two immediate changes are needed.

Recommendation 1: Institute a Commonwealth-State/Territory upskilling program at scale for out-of-field teachers of mathematics.

A collaborative national program delivered by a consortium of universities would ensure quality, consistency, cost effectiveness and uniform resourcing for teachers and schools. National recognition would allow schools to confidently acknowledge the background of teachers who complete the program. There are currently a range of courses offered for teachers to improve their capability to teaching mathematics, but these courses lack consistency and teachers are unaware or uncertain of appropriate opportunities to consider.

Recommendation 2: Concurrently create a national system for accurate and consistent data collection of every teacher's content specialisations.

Effective, evidence-based action requires ongoing accurate data on the extent of the problem of out-of-field teaching and will provide national tracking of its reduction. Consistent and national data collection can provide a source of evidence of the effectiveness of initiatives seeking to improve student outcomes in mathematics, and other subjects, related to teacher preparedness.

We recommend a full census, for example through the State and Territory teacher registration boards. This will be more reliable than the ad-hoc sample surveys currently used to report out-of-field teaching. It will provide an accurate estimate of the important fraction of classes taught out-of-field as opposed to the fraction of teachers who are out-of-field.

Call to action

It is our strong and considered view that the ministerial Education Council must now recognise the scale and urgency of this problem and its relation to overall teacher supply. The establishment of an expert advisory group by the Council, examining local and international programs, will be a vital first step in restoring equity and opportunity to the teaching and learning of mathematics in Australia.

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Endorsements

This position paper and its recommendations are endorsed by

Australian Academy of Technological Sciences and Engineering

Australian Bureau of Statistics

Australian Council of Deans of Science

Australian Institute of Physics

Computing Research & Education

Engineers Australia

Royal Australian Chemical Institute

Science Technology Australia

Endorsement letters form a separate document

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