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Out-of-field teaching in mathematics at Year 10 in New South Wales: evidence from PISA 2015¹

Chandra Shah², Helen M. G. Watt³ and Paul W. Richardson⁴

Abstract

'Out-of-field' teaching in mathematics refers to teachers who teach the subject without mathematicsspecific qualifications to do so. Out-of-field teaching has the potential to affect teachers' classroom instruction practices with consequences for student learning. This report describes the incidence and correlates of out-of-field teaching of Year 10 mathematics in New South Wales, the most populous state in Australia, relative to the rest of Australia. We draw on Australian PISA 2015 data to examine the prevalence of out-of-field teaching in relation to different teacher and school contexts. We found the qualifications profile of teachers teaching mathematics in New South Wales was different from the rest of Australia. In New South Wales 28% of Year 10 teachers were qualified to teach mathematics; 21% had one, and 79% at least two subject specialisations (corresponding proportions outside New South Wales were 34%, 6%, 94%). Yet only 19% of teachers taught Year 10 mathematics in New South Wales, with an out-of-field teaching rate of 20% (outside New South Wales the respective proportions were 16% and 19%). This suggests the co-existence of out-of-field teaching with an apparent excess supply of mathematics teachers in some schools and their potential under-utilisation. Outside New South Wales, out-of-field mathematics teaching was higher in low economic, social and cultural status (ESCS) schools with resultant cumulative disadvantage for these students In New South Wales, out-of-field teaching rates in mathematics were significantly lower for teachers who were in schools with a high (\geq 25%) versus low (< 25%) concentration of students who spoke another language than English at home, reflecting the choices recent 'aspirational' migrant parents make in relation to selective government schools that admit students based on academic abilities. These schools tend to concentrate students from high socioeconomic background and have relatively more resources available, such that they have less difficulty attracting qualified teachers. The effect of so many selective schools in New South Wales has created a two-tier division in the public school system. A key challenge for public policy is to more equitably distribute qualified teachers of mathematics to reduce the concentration of out-of-field mathematics teaching for less resourced schools in this two-tier system.

JEL classification: I20, I21, I222, I24, I28, J24

Key words: out-of-field teaching in mathematics, teacher supply and demand, secondary education

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Introduction

With continuing high demand for science, technology, engineering and mathematics (STEM) graduates in the workforce, many countries, including Australia, have concerns about whether sufficient numbers of well-qualified STEM teachers are coming through the system to meet future demand (Audit Office of New South Wales 2019; Ingersoll & Perda 2010; OECD 2012; OECD 2014; Office of the Chief Scientist 2014; Productivity Commission 2012; Queensland Audit Office 2013; The Royal Society 2007; Smith 2017). Mathematics teachers play a central role in STEM education, and therefore their quality and deployment in schools is critical to ensure all students not only gain a sound understanding of basic mathematical principles but are motivated to continue learning further mathematics and other STEM subjects which rely on mathematical skills.

Teaching quality is likely to be compromised when there is a mismatch between teachers' qualifications and the subjects they are assigned to teach. Such mismatches are often labelled 'outof-field' or 'non-specialist' teaching. Teachers teaching out-of-field are likely to lack both content knowledge and pedagogical content knowledge relative to in-field teachers (Shulman 1986). Thus, out-of-field-teaching is likely to have an effect on instructional quality and consequently student outcomes.

The assignment of a teacher to teach out-of-field can be viewed as a joint decision between the teacher and the school (Shah et al. 2022). While some teachers may prefer to teach a subject despite not being formally qualified to do so, the school often makes the final assignment decision, although some teachers may have a bigger say in this than others. When faced with tight budgets and a general shortage of mathematics teachers, the only option for some schools, given that mathematics is a compulsory subject in the curriculum until the end of Year 10, is to assign some teachers to teach the subject out-of-field. On the other hand, schools with generous budgets will have fewer difficulties hiring qualified mathematics teachers, even in tight labour markets, because they are able to offer higher salaries and better conditions (Shah et al. 2022).

The New South Wales government has been concerned about the quality of mathematics education in the state's schools. It is particularly concerned about the use of non-specialist mathematics teachers and schools' capacities for delivering quality junior secondary mathematics, where out-offield teaching is more concentrated. Although some research has been conducted on out-of-field teaching in Australia (see Shah et al. 2022; Weldon 2016), little is known at the state level in New South Wales largely because of a lack of publicly available data. The New South Wales Audit Office drew attention to the problem of out-of-field teaching in the context of monitoring the supply of and demand for teachers in the state's schools and recommended the collection of appropriate data to help more accurate monitoring of the problem (Audit Office of New South Wales 2019). Despite this recommendation, to the best of our knowledge, such data have yet to be collected.

To fill the gap in the knowledge about out-of-field teaching in mathematics in New South Wales, in this report, we use data from the 2015 Programme for International Student Assessment (PISA) survey.⁵ The analyses reported provide descriptive statistics comparing New South Wales to the rest of Australia to ascertain if systematic differences exist between them. They are also to inform the New South Wales Department of Education funded project: *Understanding and building the strengths and skills of non-specialist mathematics teachers and schools' capacities for junior secondary*

⁵ PISA 2015 were the latest data available at the time these analyses were commenced but since then PISA 2022 data, which also contain a teachers' survey, have been released.

mathematics. The results can be used to develop evidence-based policies to alleviate out-of-field teaching in junior secondary mathematics in New South Wales.

Context

A large body of literature on schooling over the last few decades has shown teacher quality to be the most important school-based factor in determining student outcomes (Goldhaber 2016; Hattie 2009; OECD 2005). Identifying aspects of teacher quality that make a difference is, however, an ongoing topic of educational research. Darling-Hammond (2012, p. i) made a distinction between *teacher* quality and *teaching* quality as follows:

Teacher quality might be thought of as the bundle of personal traits, skills, and understandings an individual brings to teaching, including dispositions to behave in certain ways. Teaching quality refers to strong instruction that enables a wide range of students to learn. Teaching quality is in part a function of teacher quality—teachers' knowledge, skills, and dispositions—but it is also strongly influenced by the context of instruction: the curriculum and assessment system; the "fit" between teachers' qualifications and what they are asked to teach; and teaching conditions, such as time, class size, facilities, and materials. If teaching is to be effective, policymakers must address the teaching and learning environment as well as the capacity of individual teachers.

Many easily measured personal traits of teachers, such as gender, age, educational attainment and licensure, have infrequently been found to directly associate with effectiveness in the classroom (Goldhaber 2016). Teachers tend to improve with experience early in their careers, but gains in teacher quality are seldom detected after five years (Goldhaber 2016). Subsequently attention has shifted to *teaching* quality to explain the effectiveness of teachers.

As Darling-Hammond (2012) pointed out, teaching quality is strongly influenced by the context of instruction. In particular, the fit between teachers' qualifications and what they are asked to teach can be an important factor in students achieving positive outcomes. Such a fit can be lacking when teachers are asked to teach out-of-field. Teachers asked to teach out-of-field are likely to lack content as well as pedagogical content knowledge, both of which are important dimensions of teaching quality (Shulman 1986). Therefore, these teachers are likely to be less effective, even if they are brilliant communicators and classroom managers. A number of empirical studies have shown that students taught by in-field teachers achieve better in mathematics than those taught by teachers teaching out-of-field (Clotfelter, Ladd & Vigdor 2010; Dee & Cohodes 2008; Goldhaber & Brewer 2000). Out-of-field teaching can affect teachers too. They are at a higher risk of leaving the profession altogether (Donaldson & Johnson 2010) and can suffer a loss of professional identity and confidence (du Plessis 2017; Hobbs 2013; Sharplin 2014).

Many studies have found substantial incidence of out-of-field teaching in mathematics when comparing teachers' qualifications with the classes they are assigned to teach. Estimates of out-of-field teaching by teachers without a major or minor in mathematics in the United States have ranged from 18% to 35% of classes, and 16% to 33% of students from 1988 to 2015 (Hill & Gruber 2011; Hill, Stearns & Owens 2015; Morton et al. 2008; Seastrom et al. 2004; Shah et al. 2019). Out-of-field teaching in mathematics among secondary school teachers in Australia has been consistently estimated to be about 20% (Shah et al. 2022; Weldon 2016). High levels of out-of-field teaching can prevent students achieving to their potential in mathematics and reduce their motivation to study at

higher levels. Teachers' influence on a young person's attitude towards mathematics and associated STEM subjects is particularly significant because parents, another big socialising influence, often claim to find these subjects difficult (The Royal Society 2007). Mathematics also tends to be less positively represented in youth culture than other subjects (The Royal Society 2007).

PISA 2015 data on teachers

This study uses data from the 2015 Programme for International Student Assessment (PISA). PISA is a triennial international survey managed by the OECD, to evaluate education systems by testing the skills and knowledge of 15-year-old students. In 2015, for the first time as part of the PISA survey, 19 countries distributed an optional questionnaire to teachers whose main activity in schools was student instruction, and another to principals. Australia was one of 72 participating countries that administered the optional surveys. The data included a common school identifier, which allowed the linking of data from the student, principal and teacher surveys from same schools. Teachers in the sample were not necessarily the teachers of the students in the sample and therefore be linked to individual students.

The survey employed a two-stage stratified design, with the first stage involving the sampling of schools in which 15-year-old students enrol and the second stage the sampling of students within these schools. Teachers eligible to take part in the survey included those who were currently teaching, had taught before, or will/could teach in the future at the Year 10 level, the modal grade for 15-year-old students.

The teacher questionnaire had questions on teachers' background, initial teacher education, professional development, teaching practices, and subjects they were teaching and qualified to teach. The principal survey had questions on school organisation, the quality of the school's human and material resources, decision-making processes, instructional practices, and school and classroom environment. Important questions in the principal survey in the context of this study related to school autonomy and staff shortage. The survey also provided contextual information about the school relating to its student population and that of students' parents.

PISA 2015 included a number of latent variables derived from responses to multiple questions by students, teachers and principals. The types of derived variables were:

- simple questionnaire indices constructed through the arithmetical transformation or recoding of one or more items and composite scores;
- derived variables based on item response theory (IRT) scaling (OECD 2017).

Most derived variables, apart from student assessments in mathematics, science and reading, were standardised to an OECD mean of zero and standard deviation of one. The analyses in this report include a number of these variables.

This report uses the Australian PISA 2015 data for students, teachers and principals from the government, Catholic and Independent schools across the eight states and territories.⁶ A sample of

⁶ The full technical details of the survey, including the sampling method, are in OECD (2017). Weights to account for the sampling design and non-response in the teacher survey were unavailable. However, student weights were available from the student survey. We used these to approximate weights for teachers. First, for each school, a school weight was calculated by summing the student weights over all students in the same school. In the second step, 13.5% of the school weight (A) was assigned to science teachers, who were oversampled in the survey, and 86.5% (B) to all other teachers. Finally, to calculate the weight for each teacher, A was divided equally over all science teachers and B over all other

14,530 Year 10 students was drawn from 758 schools to complete the student survey together with assessments of their ability to use their reading, mathematics and science knowledge. A total of 738 principals completed the school survey. The teacher sample targeted 16,234 teachers, with 11,715 completing the survey, a response rate of 72%.

The teachers' survey did not contain a specific question about out-of-field teaching in mathematics, but it included the following question:

Were any of the following [subjects] included in your teacher education or training programme or other professional qualification and do you teach them to Year 10 in the current school year?

Teachers' responses were collected in a matrix of two columns and eleven rows. The two columns were headed 'Included in my teacher education or training programme or other professional qualification' and 'Teach it to Year 10 in the current school year'. The rows listed eleven subjects, including mathematics. Respondents selected all relevant boxes in this matrix. Some teachers were assigned to teach more than one subject just as some were qualified to teach more than one subject.⁷ For each subject, a binary variable was constructed to indicate if a teacher taught the subject to Year 10 students in-field or out-of-field, with 1 indicating out-of-field teaching and 0 indicating in-field teaching.

Teachers' numbers of subject qualifications and subjects taught

Teachers in Australia generally learn the content and pedagogies to teach two subjects in their initial teacher education, although for mathematics it is common especially in New South Wales to qualify to teach only mathematics. Table 1 shows that more than half of all Year 10 teachers had qualifications to teach either one or two subjects. The percentage with qualifications to teach just one subject was significantly⁸ higher in New South Wales than in the rest of Australia; conversely, the percentage with qualifications to teach two or more subjects was significantly⁹ lower. Similarly, as Table 2 shows, while some teachers taught a single subject, others taught multiple subjects. In New South Wales, a significantly¹⁰ higher percentage of teachers taught a single subject than in the rest of Australia; the percentage who taught multiple subjects was about the same. These results point to state differences in the qualifications profile and the number of subjects taught by Year 10 teachers.

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<sup>10</sup> p-value < .01
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teachers. The 13.5% is the estimate of the proportion of science teachers in the population of all science teachers teaching at Year 10 in Australia derived from the Teaching and Learning International Survey (TALIS 2018). This survey is a representative sample of all teachers teaching at Years 7-10.

⁷ Teachers are generally assigned to teach certain classes by the school management, but this decision is sometimes influenced by teachers' choices. Management appears to put a greater weight on more senior teachers' choices (Shah et al. 2022).

⁸ *p*-value < .01

⁹ *p*-value < .05

No. of subject	Ne	w South Wa	ales	Re	st of Austra	lia	Total			
qualifications	n	%	S.E.	n	%	S.E.	N	%	S.E.	
One	923	31.4	1.1	1640	19.4	0.6	2563	23.2	0.5	
Two	783	28.3	1.0	3090	34.1	0.7	3873	32.3	0.6	
Three	494	17.3	0.9	1748	19.3	0.6	2242	18.7	0.5	
Four or more	555	19.6	0.9	2096	23.4	0.6	2651	22.2	0.5	
Non-response	84	3.4	0.4	302	3.8	0.3	386	3.6	0.2	
Total	2839	100		8876	100		11715	100		

Table 1Year 10 teachers by number of subject qualifications, New South Wales, rest of Australia and total,
2015

Source: OECD, PISA 2015 database.

Note: Weighted estimates. n refers to the sample size and S.E. to the sample error.

Table 2	Year 10 teachers b	v number of sub	iects taught. N	ew South Wales.	rest of Australia	and total, 2015
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No. of subjects	Ne	w South Wa	lles	Re	st of Austra	llia	Total			
taught	n	%	S.E.	n	%	S.E.	n	%	S.E.	
One	1370	47.3	1.1	3556	40.0	0.7	4926	42.3	0.6	
Тwo	443	16.9	0.9	1827	20.8	0.6	2270	19.6	0.5	
Three	214	7.3	0.6	683	7.4	0.4	897	7.4	0.3	
Four or more	256	8.5	0.6	549	5.6	0.3	805	6.5	0.3	
Non-response	556	20.0	0.9	2261	26.2	0.7	2817	24.2	0.5	
Total	2839	100		8876	100		11715	100		

Source: OECD, PISA 2015 database.

Note: Weighted estimates. n refers to the sample size and S.E. to the sample error.

Out-of-field teaching by subject

Table 3 shows that out-of-field teaching occurred in all subjects. While the out-of-field-teaching rate in mathematics was higher in New South Wales (20.4%) than in the rest of Australia (19.1%), the difference was not statistically significant. The overall out-of-field teaching rate in New South Wales was significantly¹¹ lower than in the rest of Australia, as it was in a number of other subjects including technology, social studies and vocational education.

The relatively low out-of-field rates in science, social studies and arts are likely because individual sub-domains that make up these subjects are not identified in the data and the consequent aggregation biases the estimates. For example, teachers who were qualified to teach biology and chemistry but were actually assigned to teach physics were considered teaching in-field in science, when in fact they were teaching out-of-field in physics. This in effect means that the estimated out-of-field teaching rates in science, social studies and arts do not reflect the true level of out-of-field teaching in their sub-domains. In some subjects, such as ancient languages, the very high rate of out-of-field teaching reflects not only a shortage of teachers in these subjects but also very low student demand to study them. Schools, especially those on tight budgets, would find it difficult to justify hiring a specialist teacher for the sake of a very few students wanting to study these

¹¹ *p*-value < .01

	Ne	w South Wa	ales	Re	st of Austra	lia	Total			
Subject		Tea out-c	ching of-field		Teac out-c	ching of-field		Teac out-c	ching of-field	
	n	%	S.E.	n	%	S.E.	Ν	%	S.E.	
Mathematics	502	20.4	2.2	1811	19.1	1.3	2313	19.5	1.1	
English	744	13.5	1.4	1876	13.8	1.0	2620	13.7	0.8	
Science ²	831	9.8	1.5	2258	9.8	1.0	3089	9.8	0.8	
Technology ³	566	15.4	1.7	1267	21.1	1.4	1833	18.9	1.1	
Social studies ⁴	401	8.5	1.6	1135	13.7	1.4	1536	12.0	1.1	
Modern languages	66	13.7	4.5	293	16.0	2.5	359	15.5	2.2	
Ancient languages⁵	9	41.5	17.9	29	87.7	6.4	38	72.2	9.0	
Arts ⁶	254	7.2	1.9	838	7.8	1.0	1092	7.6	0.9	
Physical education	276	12.3	2.2	908	13.8	1.5	1184	13.3	1.3	
Religion/ethics	180	16.4	2.9	511	36.3	2.5	691	29.5	2.0	
Vocational education ⁷	341	18.7	2.3	1030	29.9	1.7	1371	26.3	1.4	
Total	2283	13.8	0.9	6615	17.3	0.6	8898	16.1	0.5	

Table 3Out-of-field teaching among Year 10 teachers, by subject, New South Wales, rest of Australia and
total, 2015

Source: OECD, PISA 2015 database.

Notes: Weighted estimates. n refers to the sample size and S.E. to the sample error.

1 The sample size denotes the number of teacher records that contributed in the calculation of the statistics. Some teachers taught more than one subject and therefore are counted in more than one row. Consequently, the sum of the respective column is larger than the overall sample size.

2 Science includes science, physics, physical science, chemistry, biology, human biology, environmental science and agriculture/horticulture/forestry.

3 Technology includes orientation in technology, including information technology, computer studies, construction/surveying, electronics, graphics and design, keyboard skills, word processing, workshop technology and design technology.

4 Social studies include social studies, community studies, contemporary studies, economics, environmental studies, geography, history, humanities, legal studies, studies of their own country, social sciences, ethical thinking and philosophy. 5 Ancient languages include ancient Greek and Latin.

6 Arts includes arts, music, visual arts, practical art, drama, performance music, photography, drawing, creative handicraft and creative needlework.

7 Vocational education includes vocational skills (preparation for a specific occupation), technics, domestic science, accountancy, business studies, career education, clothing and textiles, driving, home economics, polytechnic courses, secretarial studies, tourism and hospitality, and handicraft.

Mathematics teachers' qualifications and subjects taught

Teachers assigned to teach mathematics at Year 10 often also taught other subjects at this level. While these other subjects were often from the STEM group, in many instances they were from the non-STEM group. In the following, we grouped subjects and qualifications into three categories: mathematics, other STEM (includes science and technology) and non-STEM (includes all non-STEM subjects). As Table 4 shows, a smaller proportion of teachers in New South Wales (28.1%) was qualified to teach mathematics than in the rest of Australia (33.6%). In each jurisdiction, about half of these teachers were qualified to teach at least two other subjects, one from 'other STEM' and the other from 'non-STEM'. Teachers' qualifications and the subjects they taught varied substantially between New South Wales and the rest of Australia.

Among teachers teaching only:

- mathematics: 46.0% were qualified to teach only mathematics in New South Wales compared with 18.9% in the rest of Australia;
- mathematics and other STEM: 73.5% were qualified to teach mathematics in New South Wales compared to 80.9% in the rest of Australia;
- non-mathematics: 13.1% were qualified to teach mathematics in New South Wales compared to 20.4% in the rest of Australia, who possibly would have taught mathematics at other Yearlevels.

Table 5 shows that in New South Wales 19.2% of all teachers taught mathematics at Year 10, sometimes in combination with other subjects. The corresponding proportion in the rest of Australia was 16.4%. Teaching mathematics together with other STEM subjects at Year 10 was relatively less common in New South Wales (1.7%) than in the rest of Australia (3.4%).

Among teachers with qualifications to teach only:

- mathematics: 84.7% in New South Wales taught mathematics compared to 66.3% in the rest of Australia;
- mathematics and other STEM: 50.5% taught mathematics and 33.4% non-mathematics subjects in New South Wales compared to 56.7% and 21.9% respectively, in the rest of Australia;
- mathematics and non-STEM: 57.2% in New South Wales taught mathematics compared to 35.1% in the rest of Australia.

		Subjects taught																			
-			New	South W	Vales					Rest	of Aust	ralia						Total			
Qualifications	Mathematics	Mathematics & other STEM	Mathematics & non- STEM	Mathematics & other STEM & non-STEM	Non-mathematics	Non-response	Total	Mathematics	Mathematics & other STEM	Mathematics & non- STEM ²	Mathematics & other STEM & non-STEM	Non-mathematics	Non-response	Total	Mathematics	Mathematics & other STEM	Mathematics & non- STEM ²	Mathematics & other STEM & non-STEM	Non-mathematics	Non-response	Total
Mathematics	46.0	0.0	4.4	0.0	0.1	3.8	5.9	18.9	1.2	1.5	0.0	0.2	1.8	2.1	30.0	1.0	2.1	0.0	0.2	2.4	3.3
Mathematics & other STEM ¹	18.8	49.4	0.0	1.6	3.2	4.7	5.9	32.3	54.2	2.8	7.0	3.0	6.5	7.9	26.8	53.3	2.2	4.8	3.1	6.0	7.3
Mathematics & non-STEM ²	12.0	3.1	31.8	5.5	1.3	3.5	3.6	17.0	0.1	29.1	3.6	4.0	5.5	5.7	15.0	0.7	29.6	4.4	3.1	5.0	5.0
Mathematics & other STEM & non-STEM	15.9	21.0	22.2	52.9	8.4	12.6	12.8	22.3	25.4	36.5	57.5	13.2	19.1	17.9	19.6	24.5	33.6	55.6	11.6	17.4	16.3
Sub-total	92.6	73.5	58.4	59.9	13.1	24.7	28.1	90.5	80.9	69.8	68.1	20.4	32.9	33.6	91.4	79.5	67.5	64.7	18.0	30.8	31.9
Non-mathematics	5.1	23.7	25.9	37.0	85.3	66.6	68.5	8.4	17.6	25.4	27.9	77.7	58.2	62.6	7.1	18.7	25.5	31.7	80.2	60.4	64.5
Non-response	2.3	2.9	15.7	3.1	1.6	8.7	3.4	1.1	1.6	4.7	4.0	1.9	8.9	3.8	1.6	1.8	7.0	3.6	1.8	8.9	3.6
Total	100	100	100	100	100.0	100	100	100	100	100	100	100	100	100	100.0	100	100.0	100.0	100	100	100
Sample size (n)	227	60	30	185	1781	556	2839	599	575	171	466	4804	2261	8876	826	635	201	651	6585	2817	11715

Table 4 Year 10 teachers by subject qualification(s), New South Wales, rest of Australia and total, 2015 (column %)

Source: OECD, PISA 2015 database.

Notes: Weighted estimates.

Standard errors have been excluded from the table but are available on request.

1 Other STEM includes science and technology.

2 Non-STEM includes English, social studies, modern languages, ancient languages, arts, physical education, religion/ethics and vocational education.

										Qu	alificatio	ons									
			New	South V	Vales					Rest	t of Aust	ralia						Total			
Subjects taught	Mathematics	Mathematics & other STEM	Mathematics & non- STEM ²	Mathematics & other STEM & non-STEM	Non-mathematics	Non-response	Total	Mathematics	Mathematics & other STEM	Mathematics & non- STEM ²	Mathematics & other STEM & non-STEM	Non-mathematics	Non-response	Total	Mathematics	Mathematics & other STEM	Mathematics & non- STEM ²	Mathematics & other STEM & non-STEM	Non-mathematics	Non-response	Total
Mathematics	84.7	34.9	36.7	13.5	0.8	7.5	10.9	66.3	29.6	21.6	9.0	1.0	2.1	7.3	76.7	31.0	25.0	10.2	0.9	3.7	8.4
Mathematics & other STEM ¹	0.0	14.2	1.5	2.8	0.6	1.4	1.7	2.0	23.2	0.1	4.8	1.0	1.4	3.4	0.9	20.9	0.4	4.3	0.8	1.4	2.9
Mathematics & non-STEM	0.9	0.0	10.9	2.1	0.5	5.7	1.2	1.6	0.8	11.2	4.5	0.9	2.7	2.2	1.2	0.6	11.1	3.9	0.7	3.6	1.9
Mathematics & other STEM & non-STEM ²	0.0	1.4	8.1	22.1	2.9	4.9	5.3	0.0	3.1	2.2	11.3	1.6	3.7	3.5	0.0	2.7	3.5	14.0	2.0	4.1	4.1
Sub-total	85.6	50.5	57.2	40.5	4.7	19.6	19.2	69.9	56.7	35.1	29.6	4.4	10.0	16.4	78.8	55.1	40.1	32.3	4.5	12.8	17.3
Non-mathematics	1.4	33.4	22.9	39.8	75.8	28.7	60.8	6.8	21.9	39.8	42.4	71.3	28.2	57.5	3.7	24.9	36.0	41.8	72.8	28.4	58.5
Non-response	13.0	16.1	19.9	19.7	19.5	51.7	20.1	23.3	21.4	25.1	28.0	24.3	61.8	26.2	17.5	20.0	24.0	25.9	22.7	58.9	24.2
Total	100	100	100	100	100.0	100	100	100	100	100	100	100	100	100	100.0	100	100.0	100.0	100	100	100
Sample size (n)	124	242	78	439	1872	84	2839	154	1211	413	1897	4899	302	8876	278	1453	491	2336	6771	386	11715

Table 5 Year 10 teachers by subject(s) taught, New South Wales, rest of Australia and total, 2015 (column %)

Source: OECD, PISA 2015 database.

Notes: Weighted estimates.

Standard errors have been excluded from the table but are available on request.

1 Other STEM includes science and technology.

2 Non-STEM includes English, social studies, modern languages, ancient languages, arts, physical education, religion/ethics and vocational education.

Out-of-field teaching in mathematics

Year 10 teachers of mathematics often taught other subjects at this Year-level. Table 6 shows that the out-of-field teaching rate in mathematics was much higher among teachers teaching mathematics in combination with other subjects than among teachers teaching only mathematics, with the differences in the rates larger in New South Wales than the rest of Australia. Calculations not shown in the table showed that relatively more teachers in New South Wales (27.8%) were assigned to teach a combination of mathematics, other STEM and non-STEM subjects than in the rest of Australia (21.5%).¹²

		•	• •							
	Ne	w South Wa	lles	Re	st of Austra	lia	Total			
- Subjects taught		Teac mathe out-c	ching ematics of-field		Teac mathe out-o	ching ematics of-field		Teaching mathematics out-of-field		
	n	%	S.E.	n	%	S.E.	n	%	S.E.	
Mathematics only	227	7.4	2.0	599	9.5	1.9	826	8.6	227	
Mathematics & other STEM ¹	60	26.5	6.5	575	19.1	2.3	635	20.5	60	
Mathematics & non- STEM ²	30	41.6	10.2	171	30.2	4.4	201	32.5	30	
Mathematics & other STEM & non-STEM	185	40.1	4.5	466	31.9	2.9	651	35.3	185	
Total	502	20.4	2.2	1811	19.1	1.3	2313	19.5	502	

Table 6Out-of-field teaching among Year 10 teachers of mathematics by subjects taught, New South Wales,
rest of Australia and total, 2015 (%)

Source: OECD, PISA 2015 database.

Notes: Weighted estimates. n refers to the sample size and S.E. to the sample error.

1 Includes science and technology.

2 Includes English, social studies, modern languages, ancient languages, arts, physical education, religion/ethics or vocational education.

Demographic characteristics

Out-of-field teaching rates in mathematics varied by teachers' background characteristics (see Table 7). Rates were higher for younger than older teachers: the 31.3% rate for teachers aged 30-39 years in New South Wales was significantly¹³ higher than the 18.9% rate for the same age group in the rest of Australia. However, out-of-field teaching rates were similar for teachers on fixed-term and permanent contracts, part-time and full-time teachers, also for men and women.

Teachers were asked if their post-school career goal had been to teach. Out-of-field mathematics teaching was marginally related to this¹⁴, but only outside New South Wales. If such teachers appear more dedicated, they may have more agency with their school administration as to what subjects they teach and schools may be aiming to retain them by assigning them to teach in-field.

Three measures of teacher experience were available in the data: total number of years teaching, number of years teaching in their current school, and number of schools taught in. While there was a strong correlation (r = .65) between total teaching experience and teaching experience in the current

¹² These are weighted proportions.

¹³ *p*-value < .05

¹⁴ *p*-value < .10

school, there was a weak correlation between number of schools taught in and each of total years of teaching experience (r = .40), and years in current school (r = .05).

Out-of-field teaching rates were higher for least experienced (≤ 2 years) than most experienced teachers (≥ 6 years), but were not significantly related to years taught in their current school.¹⁵ Paradoxically, the out-of-field teaching rate was lower for teachers in their first than their second school in New South Wales¹⁶, but not elsewhere.

Consistent with the results in Table 6, teachers teaching more than one subject at Year 10 were significantly¹⁷ more likely to be teaching mathematics out-of-field, particularly in New South Wales. On the other hand, the pattern of out-of-field teaching rates was more complex. In New South Wales, the rate was only 13.1% for teachers with a single subject qualification, increasing to about 20% for teachers with two or more qualifications. Elsewhere, the rate declined significantly¹⁸ from 40.2% for teachers with a single subject qualification to 11.6% for those with three or more qualifications.

¹⁵ The difference in the rates were significant with *p*-value < .05 for the first measure, but only in the sample outside New South Wales and with *p*-value < .10 for the second measure in samples for both jurisdictions.

¹⁶ *p*-value < .05

¹⁷ *p*-value < .01

¹⁸ *p*-value < .01

	Ne	w South Wa	les	Re	st of Austra	lia		Total	
Teacher characteristic		Teac out-o	ching f-field		Teac out-o	ching f-field		Teac out-o	ching f-field
	n	%	S.E.	n	%	S.E.	n	%	S.E.
Gender									
Female	254	20.6	2.9	871	21.6	2.1	1125	21.2	1.7
Male	246	20.1	3.2	929	16.9	1.6	1175	18.0	1.6
Age									
20-29 years	87	26.1	5.2	294	24.6	3.3	381	25.1	2.8
30-39 years	105	31.3	5.7	442	18.9	2.4	547	22.7	2.4
40-49 years	137	22.4	4.2	450	21.2	2.5	587	21.6	2.2
≥ 50 years	170	11.7	3.1	617	15.8	2.4	787	14.3	1.9
Qualification level									
Below bachelor	25	12.4	7.0	86	19.6	5.1	111	17.1	4.1
Bachelor	354	22.3	2.7	1415	19.0	1.5	1769	20.0	1.3
Above bachelor	122	16.5	4.0	298	18.0	3.1	420	17.3	2.5
Contract									
Permanent	423	19.2	2.3	1546	18.4	1.4	1969	18.7	1.2
Fixed-term	78	26.2	7.1	262	23.9	3.5	340	24.9	3.6
Hours									
Full-time	439	21.0	2.3	1531	19.0	1.5	1970	19.7	1.2
Part-time	59	15.8	5.7	263	19.1	3.1	322	17.9	2.9
Teaching experience									
≤ 2 years	30	27.3	9.1	152	29.7	5.0	182	29.0	4.4
3-5 years	65	21.6	5.9	224	18.7	3.3	289	19.7	3.0
≥ 6 years	404	19.9	2.4	1403	17.9	1.5	1807	18.6	1.3
Teaching experience (in current school)									
≤ 2 years	92	29.8	5.4	422	22.4	2.8	514	24.6	2.6
3-5 years	121	17.8	4.5	431	21.9	2.7	552	20.4	2.4
≥ 6 years	283	18.1	2.7	930	16.6	1.8	1213	17.1	1.5
Teaching experience (no. of schools)									
1	56	11.9	4.0	272	17.3	3.0	328	15.6	2.4
2	84	25.7	5.5	295	23.6	3.1	379	24.3	2.8
≥ 3	346	19.5	2.6	1159	18.1	1.7	1505	18.6	1.4
Post-school career teaching									
Yes	257	20.8	3.0	732	16.5	1.8	989	18.2	1.6
No	245	19.9	3.1	1073	20.9	1.9	1318	20.6	1.6
No. of subjects assigned to teach									
1	227	7.4	2.0	599	9.5	1.9	826	8.6	1.4
2	57	29.3	7.3	616	22.1	2.5	673	23.3	2.4
≥ 3	218	40.1	4.1	596	31.3	2.6	814	34.7	2.3
No. of subjects qualified to teach									
0	16	100.0	0.0	40	100.0	0.0	56	100.0	0.0
1	128	13.1	3.1	233	40.2	4.2	361	25.9	2.9
2	120	21.9	4.1	678	15.1	1.8	798	17.0	1.7
≥ 3	238	18.1	3.2	860	11.6	1.8	1098	13.7	1.6
Total	502	20.4	2.2	1811	19.1	1.3	2313	19.5	1.1

Table 7	Out-of-field teaching among Year 10 teachers of mathematics by background characteristics, New
	South Wales, rest of Australia and total, 2015 (%)

Source: OECD, PISA 2015 database.

Note: Weighted estimates. n refers to the sample size and S.E. to the sample error.

Professional development

There was little evidence to suggest undertaking various professional development activities was associated with out-of-field teaching of mathematics (see Table 8). There was weak evidence¹⁹ and only outside New South Wales, that out-of-field mathematics teachers were more likely to undertake a qualification programme. Unfortunately, no information is available about whether the qualification programme was for teaching mathematics or some other subject. In New South Wales, out-of-field teachers appeared marginally overrepresented among those who undertook professional development activities involving individual or collaborative research on a topic of professional interest.²⁰

	Ne	w South Wa	les	Re	st of Austra	lia		Total	
Professional development activity		Teac out-o	ching f-field		Teac out-o	ching f-field		Teac out-o	ching f-field
	n	%	S.E.	n	%	S.E.	n	%	S.E.
Qualification programme									
No	417	19.4	2.4	1506	17.5	1.4	1923	18.2	1.2
Yes	47	29.3	7.6	180	25.7	4.6	227	26.9	3.9
Networking with teachers for professional development									
No	125	18.6	4.6	447	16.3	2.4	572	17.2	2.3
Yes	360	19.9	2.4	1317	19.2	1.6	1677	19.4	1.3
Individual or collaborative research on topic of professional interest									
No	260	16.8	2.6	879	16.6	1.6	1139	16.7	1.4
Yes	213	25.5	3.8	843	19.2	2.1	1056	21.2	1.9
Mentoring and/or peer observation and coaching, as part of a formal school arrangement									
No	165	18.0	3.9	418	14.6	2.2	583	16.1	2.1
Yes	320	21.8	2.7	1336	20.1	1.6	1656	20.6	1.4
Reading professional literature (e.g., journals, evidence- based papers)									
No	156	18.6	3.8	408	19.4	3.2	564	19.1	2.5
Yes	322	21.3	2.7	1356	17.9	1.4	1678	19.0	1.3
Engaging in informal dialogue with colleagues on how to improve teaching									
No	15	4.8	3.9	42	15.8	7.1	57	11.1	4.6
Yes	482	21.1	2.3	1745	18.7	1.3	2227	19.5	1.2
Total	502	20.4	2.2	1811	19.1	1.3	2313	19.5	1.1

Table 8	Out-of-field teaching among Year 10 teachers of mathematics by professional development activity,
	New South Wales, rest of Australia and total, 2015 (%)

Source: OECD, PISA 2015 database.

Note: Weighted estimates. n refers to the sample size and S.E. to the sample error.

¹⁹ *p*-value < .10

²⁰ *p*-value < .10

Schools' capacity to provide instruction

Teachers were asked if their school's capacity to provide instruction to students was hindered by either a lack of teachers, or educational material in the school. The questions were asked in general, not specific to mathematics. Table 9 shows that more teachers teaching mathematics out-of-field believed a lack of teaching staff hindered the school's capacity to provide instruction, although the difference was only statistically significant²¹ outside New South Wales.

	Ne	w South Wa	les	Re	st of Austra	lia	Total			
School's capacity to provide instruction		Teac out-o	Teaching out-of-field		Tead out-o	ching f-field		Teac out-o	ching f-field	
	n	%	S.E.	n	%	S.E.	n	%	S.E.	
Lack of teaching staff										
No	413	18.1	2.1	1367	16.4	1.2	1780	17.0	1.1	
Yes	87	25.2	5.1	434	23.3	2.6	521	23.8	2.3	
Inadequate or poorly qualified teaching staff										
No	404	18.0	2.1	1358	17.2	1.3	1762	17.5	1.1	
Yes	93	24.6	5.0	436	19.6	2.5	529	21.0	2.3	
Inadequate educational material										
No	361	17.6	2.1	1299	16.3	1.2	1660	16.7	1.1	
Yes	140	23.6	4.1	500	23.6	2.5	640	23.6	2.2	
Total	502	20.4	2.2	1811	19.1	1.3	2313	19.5	1.1	

Table 9	Out-of-field teaching among Year 10 mathematics teachers, by schools' capacity to provide
	instruction, New South Wales, rest of Australia and total, 2015 (%)

Source: OECD, PISA 2015 database.

Note: Weighted estimates. n refers to the sample size and S.E. to the sample error.

The category 'No' includes 'very little' and 'not at all' responses; the category 'Yes' includes 'to some extent' and 'a lot'.

Job satisfaction

The teachers' survey included a series of questions on their feelings about their jobs. Teachers teaching mathematics out-of-field may have negative feelings due to less confidence teaching subjects outside their field. Although teachers who had less favourable views about their jobs appeared to be more likely to be teaching mathematics out-of-field (see Table 10), the differences were generally not statistically significant. Responses to some questions in Table 10 were aggregated to construct two summary scales: overall satisfaction with job²² and overall satisfaction with teaching²³. Only outside New South Wales, the average satisfaction with job was significantly²⁴ higher for in-field than out-of-field teachers. However, average satisfaction with teaching was similar for infield and out-of-field teachers in both jurisdictions.

²¹ *p*-value < .05

²² Derived variable uses IRT scaling and responses to four items: 1) I enjoy working at this school, 2) I would recommend my school as a good place to work, 3) I am satisfied with my performance in this school, and 4) All in all, I am satisfied with my job.

²³ Derived variable uses IRT scaling and responses to four items: 1) The advantages of being a teacher clearly outweigh the disadvantages, 2) If I could decide again, I would still choose to work as a teacher, 3) I regret that I decided to become a teacher, and 4) I wonder whether it would have been better to choose another profession.

²⁴ *p*-value < .01

	New South Wales			Re	st of Austra	lia	Total		
Job satisfaction		Teac out-o	ching f-field		Teaching out-of-field			Teaching out-of-field	
	N	%	S.E.	n	%	S.E.	n	%	S.E.
Advantages of being a teacher clearly outweigh disadvantages									
Disagree	82	23.4	5.4	236	21.7	3.3	318	22.4	3.0
Agree	417	20.6	2.3	1564	18.8	1.4	1981	19.4	1.2
If I could decide again, I would still choose to work as a teacher									
Disagree	102	28.3	5.4	368	19.5	2.5	470	22.5	2.5
Agree	392	19.0	2.3	1425	19.0	1.5	1817	19.0	1.3
Regret becoming a teacher									
Disagree	459	21.2	2.3	1663	19.2	1.4	2122	19.9	1.2
Agree	40	20.4	7.0	136	17.3	4.1	176	18.4	3.6
Enjoy working at current school									
Disagree	45	34.0	8.6	144	27.1	4.8	189	29.9	4.5
Agree	453	19.7	2.2	1655	18.5	1.4	2108	18.9	1.2
Would have been better to choose another profession									
Disagree	308	20.7	2.7	1094	17.7	1.7	1402	18.8	1.5
Agree	190	22.0	3.6	705	21.5	2.1	895	21.7	1.8
Recommend school as good place to work									
Disagree	80	21.7	5.1	238	26.6	4.0	318	24.5	3.2
Agree	418	21.1	2.4	1561	18.0	1.4	1979	19.0	1.2
Satisfied with own performance in current school									
Disagree	26	33.1	10.4	81	16.2	4.3	107	23.4	5.3
Agree	473	20.3	2.2	1718	19.3	1.4	2191	19.7	1.2
Overall satisfied with job									
Disagree	50	31.5	8.0	169	21.7	4.0	219	25.0	3.8
Agree	448	20.0	2.2	1624	18.8	1.4	2072	19.2	1.2
Total	502	20.4	2.2	1811	19.1	1.3	2313	19.5	1.1

Table 10 Out-of-field teaching among Year 10 mathematics teachers, by job satisfaction, New South Wales, rest of Australia and total, 2015 (%)

Source: OECD, PISA 2015 database.

Note: Weighted estimates. n refers to the sample size and S.E. to the sample error.

The category Disagree includes 'disagree' and 'strongly disagree' responses; Agree includes 'agree' and 'strongly agree'.

School contexts

School-level data from administrative sources and the principals' survey were linked to teachers' data to investigate how out-of-field teaching rates in mathematics varied by school context factors.

School sector

The results of these analyses, presented in Table 11, show the rates for teaching mathematics out-offield in the independent sector were significantly²⁵ lower than in the government sector outside New South Wales, but not within New South Wales. Shah et al. (2022) concluded that these results are a consequence of the inequitable access to resources that schools have across sectors. When private and public funding sources are combined, non-government schools (especially independent schools) are much better funded than government schools (Thomson 2021). According to Shah et al. (2022), the better funding enables these schools to develop long-term plans for recruitment and retention of qualified staff. It also allows them to operate a staffing policy with a built-in spare capacity to meet short-term needs. Thus, unlike government schools whose budgets are invariably tight, on average, independent schools have enough resources so as not to rely on the short-term teacher labour market and risk not being able to find qualified teachers at short notice.

Geographic location

Three geographic locations of schools were defined in the data – metropolitan, provincial and rural. There were no schools in rural locations in New South Wales in the sample which somewhat limits the comparison of out-of-field teaching across locations in the state. In New South Wales, teachers in provincial and metropolitan schools had similar rates of out-of-field teaching. However, across the rest of Australia, teachers in rural schools were significantly²⁶ more likely to be teaching out-of-field than those in provincial and metropolitan schools. The sparse population in rural areas means schools are smaller and teacher labour markets are thinner. Rural schools face these dual problems. Combined with this is the fact that mathematics is a compulsory subject in the curriculum until the end of Year 10. Schools are obliged to provide minimum instruction in this compulsory subject to all students, but they are not required to provide the instruction by specialist mathematics teachers. Consequently, schools often have to resort to assigning teachers to teach out-of-field in mathematics.

School type

About 16% of schools in the PISA 2015 sample were single-sex. The Catholic sector contained the highest proportion of teachers in single-sex schools, followed by the independent sector. In New South Wales, out-of-field teaching appeared highest for teachers in boys-only schools, and lowest in girls-only schools, but the differences in rates were not statistically significant. Outside New South Wales, the rate was significantly²⁷ lower for teachers in each of girls-only and boys-only than coeducational schools.

²⁵ *p*-value < .01

²⁶ *p*-value < .05

²⁷ *p*-value < .05

School size

School size mattered when it came to whether a teacher was assigned to teach out-of-field. Out-offield teaching rates generally declined with school size, but only outside New South Wales (likely related to the absence of rural schools in the New South Wales sample). The rate for teachers in the largest schools (> 1500) outside New South Wales were significantly²⁸ lower than for teachers in schools with 1000 or fewer students. Smaller schools have the problem of economy of scale, which makes it difficult for them to employ specialist teachers across all subjects, and consequently often have to resort to assigning teachers to teach out-of-field in large compulsory subjects such as mathematics.

Cultural diversity

Two measures of cultural diversity were measured: the proportion of Indigenous students, and proportion of students who speak a language other than English at home. Out-of-field rate teaching in mathematics was significantly²⁹ higher in schools containing high ($\geq 25\%$) concentration of Indigenous students than schools with a low (< 25%) concentration, but only outside New South Wales. In New South Wales, out-of-field teaching of mathematics was significantly³⁰ lower in schools with a high ($\geq 25\%$) concentration of students who spoke a language other than English at home, than schools with a low (< 25%) concentration. While on first reflection this result may seem counterintuitive, it may be explained in the context of recent migration patterns to Australia. Many students who speak a language other than English at home seem counterintuitive, it may be explained in the context of recent migration patterns to Australia. Many students who speak a language other than English at home seem counterintuitive, it may be explained in the context of recent migration patterns to Australia. Many students who speak a language other than English at home seem counterintuitive, it may be explained in the context of recent migration patterns to Australia. Many students who speak a language other than English at home are from families who recently migrated, especially from East, South East and South Asia. These families are highly 'aspirational' and tend to enrol their children in high-performing, well resourced, non-government schools or selective³¹ government schools (Ho 2020).

Parental education

Parental education is clearly related to the level of resources available to schools, and resources do matter to how many teachers teach out-of-field. Highly educated parents are usually over-represented in non-government and selective government schools. Table 11 shows that out-of-field teaching rates were lower in schools having higher concentrations of highly educated parents. However, the difference in rates between high (\geq 75%) and low (< 75%) concentration schools was significant³² only outside New South Wales.

Vocational education

The percentage of students enrolled in vocational education subjects varied across schools. In New South Wales, only 3% of teachers were in schools where 25% or more students were undertaking vocational education subjects; the corresponding proportion in the rest of Australia was 23%. Such a large difference between New South Wales and other jurisdictions is unlikely to be due to sampling error and suggests systemic differences in the curriculum offered by schools and students' preferences. The out-of-field teaching rate was significantly³³ higher in schools containing high

³³ *p*-value < .01

²⁸ *p*-value < .05

²⁹ *p*-value < .01

³⁰ *p*-value < .01

³¹ Selective high schools include: 1) fully selective (coeducational and single sex), 2) partially selective, 3) agricultural (coeducational, day, boarding and boys only), and 4) virtual selective (https://education.nsw.gov.au/public-schools/selective-high-schools-and-opportunity-classes/year-7/what-are-selective-high-schools/list-of-selective-high-schools).

 $^{^{32}}$ *p*-value < .01

(≥ 75%) concentrations of students enrolled in vocational subjects than schools with low (< 25%) concentrations, outside New South Wales.

	Ne	w South Wa	les	Re	st of Austra	lia	Total		
- School context		Teaching out-of-field			Teaching out-of-field			Teaching out-of-field	
	n	%	S.E.	n	%	S.E.	n	%	S.E.
Sector									
Government	307	19.9	2.7	1074	22.4	1.9	1381	21.4	1.6
Catholic	126	20.7	4.3	396	18.8	2.4	522	19.5	2.3
Independent	69	22.1	6.3	341	10.2	1.9	410	13.4	2.2
Location ¹									
City	384	19.9	2.3	1242	17.8	1.6	1626	18.6	1.3
Provincial	118	21.7	5.2	500	21.0	2.5	618	21.2	2.4
Rural	0	0.0	0.0	69	36.2	7.4	69	36.2	7.4
School type									
Coeducational	415	20.2	2.4	1621	20.1	1.4	2036	20.2	1.2
Girls only	38	11.8	6.5	103	9.9	3.2	141	10.8	3.4
Boys only	49	28.1	7.7	87	11.5	3.7	136	19.7	4.5
School size									
< 501 students	58	28.6	7.0	201	28.4	4.6	259	28.5	4.0
501-1000 students	230	18.9	3.0	658	21.4	2.6	888	20.4	2.0
1001-1500 students	172	19.0	3.6	578	17.1	1.9	750	17.8	1.8
> 1500 students	19	0.0	0.0	241	12.6	2.6	260	11.3	2.4
No. Indigenous students									
< 25%	354	20.0	2.5	1359	17.0	1.4	1713	18.0	1.3
≥ 25%	148	21.2	4.4	452	25.9	3.1	600	24.0	2.6
No. students speaking a language other than English at home									
< 25%	420	22.4	2.5	1625	19.4	1.4	2045	20.5	1.3
≥ 25%	82	9.7	3.4	175	15.9	3.5	257	13.0	2.5
No. students' parents with higher education qualifications									
< 75%	424	20.7	2.4	1616	20.5	1.5	2040	20.6	1.3
≥ 75%	78	18.5	5.5	186	9.7	2.5	264	13.2	2.7
No. students studying vocational subjects									
< 25%	493	20.5	2.2	1370	16.7	1.5	1863	18.3	1.3
≥ 25%	9	13.8	11.5	436	26.0	2.8	445	25.5	2.8
Total	502	20.4	2.2	1811	19.1	1.3	2313	19.5	1.1

Table 11	Out-of-field teaching among Year 10 mathematics teachers, by school context, New South Wales,
	rest of Australia and total, 2015 (%)

Source: OECD, PISA 2015 database.

Note: Weighted estimates. n refers to the sample size and S.E. to the sample error.

1 Metropolitan classified as location with population greater than 100,000, provincial with between 25,000 and 100,000 and rural with less than 25,000.

Other school factors

Finally, four derived school context latent factors were associated with out-of-field teaching in mathematics:

- school's economic, social, cultural status (ESCS)³⁴;
- school's mathematics literacy score³⁵;
- staff shortage: scale constructed from principals' responses to questions on whether staff shortage hindered the provision of instruction to students;
- school autonomy: scale constructed from principals' responses to questions related to autonomy in making decisions about the administration of the school.

As with the other school context factors, these data were linked to teachers' responses using the unique school identifier. Table 12 presents results of analyses comparing the means of these variables for in-field and out-of-field teachers of mathematics.

There was a clear link between ESCS and out-of-field mathematics teaching, with low ESCS students significantly³⁶ more likely to be taught by out-of-field teachers in mathematics, but only outside New South Wales. The distribution of out-of-field teaching across students was clearly non-random, with low ESCS students disproportionately affected by out-of-field teaching. Thomson (2021) showed that the mathematics literacy of students correlated with their ESCS. It is therefore unsurprising to find the mean mathematics literacy was higher in schools where teachers taught in-field than in schools where they taught out-of-field, although, again, the difference was statistically significant³⁷ only outside New South Wales.

The staff shortage question to principals was about staff in general and not specific to mathematics. A closer examination of the scale showed its distribution was highly skewed, with a spike at one particular extreme negative value. This means caution is required when interpreting any results of statistical tests which assume normal distributions. A similar caution applies to the school autonomy scale whose distribution was also skewed. Notwithstanding, staff shortage seemed to be, on average, a lesser problem in schools where teachers taught mathematics in-field than in schools where they taught mathematics out-of-field, however the difference was statistically significant³⁸ only outside New South Wales. A similar question was asked of teachers, and analyses showed that teachers who perceived a staff shortage were also more likely to be teaching out-of-field, again only outside New South Wales. Principal-reported school autonomy was significantly³⁹ higher in schools where teachers taught mathematics in-field than out-of-field, only outside New South Wales.

³⁴ Derived using principal component analysis of three items from the students' survey: 1) parental education, 2) parental occupation, and 3) home possessions. A school's ESCS was the average ESCS over all students in the school.

³⁵ The PISA 2015 survey measured students' ability to use their reading, mathematics and science knowledge. For each of these three domains, 10 standardised plausible values were provided. For sake of simplicity, we used the first plausible value of the mathematics literacy score. A school's mathematics literacy score was the average score over all students in the school.

³⁶ *p*-value < .01

³⁷ *p*-value < .05

³⁸ *p*-value < .05

³⁹ *p*-value < .05

Cabaal aantast aaala	New Sout	th Wales	Rest of A	ustralia	Total	
School context scale -	Mean	S.E.	Mean	S.E.	Mean	S.E.
Economic, social and cultural status (ESCS) of students ¹						
In-field teachers	0.235	0.026	0.224	0.016	0.228	0.014
Out-of-field teachers	0.182	0.052	0.081	0.029	0.118	0.027
Student mathematics literacy score ²						
In-field teachers	487	4	492	2	490	2
Out-of-field teachers	479	6	470	3	473	3
Staff shortage ³						
In-field teachers	-0.439	0.059	-0.303	0.040	-0.349	0.033
Out-of-field teachers	-0.288	0.112	-0.109	0.072	-0.174	0.061
School autonomy4						
In-field teachers	0.672	0.032	0.774	0.009	0.738	0.014
Out-of-field teachers	0.726	0.027	0.736	0.014	0.733	0.013

Table 12 Mean and standard error of school context scales, by in-field and out-of-field Year 10 mathematics teachers, New South Wales, rest of Australia and total

Source: OECD, PISA 2015 database.

Note: Weighted estimates. S.E. refers to the standard error.

1 Derived using principal component analysis of three items: 1) parental education, 2) parental occupation, and 3) home possession. The ESCS of all students in a school were averaged to derive the school ESCS index.

2 The mathematics literacy scores of all students in a school were averaged to derive the school PISA index. For sake of simplicity, only the first plausible value has been used.

3 Derived based on IRT scaling and responses to items on the availability of staff (both teaching and assisting) and their qualifications. Measures whether staff shortage hinders provision of instruction to students in schools.

4 Derived as simple composite index based on principals' responses to questions on 1) hiring and firing of teachers, 2) setting staff salaries, 3) formulating and deciding budget allocation, 4) course content and curricula, 5) student assessment policies, and 6) student discipline policies.

Concluding comments

This report utilised data from the PISA 2015 surveys of students, teachers and principals to compare out-of-field teaching in mathematics at Year 10 in New South Wales with the rest of Australia. The assessment of out-of-field teaching was based on the responses teachers provided about subjects they taught at Year 10 and their qualifications.

The qualifications profile of teachers in New South Wales was different from the rest of Australia. More than half of all teachers were qualified to teach either one or two subjects in both jurisdictions. However, the percentage qualified to teach just one subject was significantly higher in New South Wales; in particular, the proportion of mathematics teachers who also qualified to teach other subjects was substantially lower than in the rest of Australia. These qualification differences were reflected in the assignment of teachers to subjects in New South Wales compared to other jurisdictions.

In New South Wales, out-of-field teaching rates in mathematics were significantly lower for teachers who were:

- working in their first versus their second school;
- teaching a single subject rather than multiple subjects at Year 10;
- in schools with a high (≥ 25%) concentration of students who spoke a language other than English at home than schools with a low (< 25%) concentration.

A total of 28.1% teachers in the sample for New South Wales were qualified to teach mathematics yet 19.2% taught the subject at Year 10, and 20.4% of those teaching mathematics were teaching it outof-field (the respective proportions in the rest of Australia were 33.6%, 16.4% and 19.1%). Further, quite a number of teachers with mathematics qualifications in each jurisdiction taught only nonmathematics subjects at Year 10, although some would, surely, be teaching mathematics at other levels. These statistics underscore not only the differences that exist in the qualification profiles and the assignment of teachers to classes across jurisdictions, but the co-existence of out-of-field teaching with an apparent excess supply of mathematics teachers in some schools and their potential under-utilisation. The explanation for the contradiction lies in the uneven distribution of the supply of and demand for mathematics teachers across schools. A key challenge for public policy is to manage the distribution of qualified mathematics teachers across the system, to minimise effects of out-of-field teaching on students equitably.

Out-of-field teaching could be reduced if more teachers, especially in New South Wales, were required to study content knowledge and pedagogical content knowledge for more than one subject. If teachers have qualifications to teach more than one subject, it can provide schools with extra degrees of freedom to optimise the allocation of teachers to classes. However, there is a risk in requiring teachers to learn the content and pedagogies of too many subjects in terms of sacrificing depth of knowledge, that affects their teaching and may inspire their students to study mathematics.

Out-of-field teaching occurred across all subjects. When comparing rates of out-of-field teaching across subjects, it is important to understand whether it is an aggregate of sub-domains, and student demand for the subject. Although out-of-field teaching in mathematics appeared higher in New South Wales than the rest of Australia, this difference was not statistically significant. Out-of-field teaching rates in technology, social studies and vocational education were significantly lower in New South Wales.

Some teacher characteristics were strongly associated with out-of-field teaching in mathematics. Younger teachers were more often assigned to teach mathematics out-of-field, consistent with results related to teacher experience. Seniority, it seems, gives agency to teachers to choose classes they wish to teach. This interpretation assumes most teachers have a preference for teaching in-field. Relatedly, although only outside New South Wales, in-field teachers of mathematics were more satisfied with their jobs. Collectively, these results suggest that some teachers have more input into schools' decisions about what they teach than others. Further qualitative research may help explain these results.

Aspects of school context also associated with out-of-field teaching in mathematics. Out-of-field teaching rates were significantly lower in independent than government schools, but only outside New South Wales. This could possibly be due to the different structure of government schools in New South Wales which, unlike the rest of Australia, includes a large number of selective schools, mostly in metropolitan areas, providing a public alternative to private schools for some parents. Like independent schools, these tend to concentrate students from high socioeconomic backgrounds and are often a choice for 'aspirational' parents, who speak a language other than English at home. Selective schools' incomes are often topped up by higher subject fees and voluntary parental contributions relative to incomes of comprehensive schools. The concentration of high ability students means selective schools have less difficulty attracting highly qualified and experienced teachers. The effect of so many such schools in New South Wales is to create a two-tier division in the public school system and possibly increase the variation in out-of-field teaching rates across schools.

Our analyses identified some structural factors associated with out-of-field mathematics teaching, including the location of the school and its size. Most smaller schools lack sufficient resources to hire specialist subject teachers and resort to assigning teachers to out-of-field teaching, especially in large compulsory subjects such as mathematics. Classes in non-compulsory subjects can be cancelled if specialist teachers are unavailable, but cancellation is more difficult in compulsory subjects. Rural schools have the added problem of thin teacher labour markets due to their location. Unfortunately, there were no rural New South Wales schools in the sample to draw state-based conclusions.

Only outside New South Wales, the mean ESCS of schools was lower where teachers taught out-offield. Together with lower mathematics literacy (which correlated with average ESCS), this suggests inequity in the system where lower ESCS students are disproportionately affected by out-of-field teaching in mathematics, and may become further disadvantaged by cumulative impacts of out-offield teaching.

School incomes relate to some of the factors that associated with out-of-field teaching. In particular, independent schools and schools with a high proportion of high ESCS students tend to have more private sources of income than other schools. Together with government funding, this allows these schools to be more effective in recruiting and retaining qualified, experienced teachers in a tight labour market for mathematics teachers. They have a competitive edge over other schools because they are able to offer better pay or conditions to teachers. More resources allow some of these schools to have an excess supply of qualified teachers on their staffing who can be deployed at short notice to meet needs and avoid out-of-field teaching. Schools with limited resources have to compete in the casual teachers' labour market with its inherent risks of not finding teachers qualified in the subject of need.

Out-of-field teaching in mathematics, or any subject for that matter, could be avoided if schools had unlimited budgets and there was no lack of supply of qualified teachers to entice with appropriate rewards to move where there was a need. Unfortunately, education budgets are always going to be limited, and the structural and systemic problems at the school system level means out-of-field teaching will probably always exist and have to be managed. While some increase in the overall level of school funding and additional supply of mathematics teachers can help reduce out-of-field teaching, a key challenge for public policy is how to manage the allocation problem to minimise potential negative impacts on students equitably. Requiring new mathematics teachers to qualify to teach two subjects, especially in New South Wales, and current, willing teachers to acquire skills and knowledge to teach an additional subject that is in demand could certainly help in this regard.

References

- Audit Office of New South Wales 2019, *Supply of secondary teachers in STEM-related disciplines*, Author, Sydney, viewed 25 April 2019, <u>https://www.audit.nsw.gov.au/sites/default/files/pdf-downloads/Final%20Report%20-%20Supply%20of%20secondary%20teachers%20in%20STEM-related%20disciplines%20v2.pdf.</u>
- Clotfelter, CT, Ladd, HF & Vigdor, JL 2010, 'Teacher credentials and student achievement in high school: A cross-subject analysis with student fixed effects', *The Journal of Human Resources*, vol. 45, pp. 655-681, <u>www.jstor.org/stable/25703472</u>.
- Darling-Hammond, L 2012, Creating a comprehensive system for evaluating and supporting effective teaching, Stanford Center for Opportunity Policy in Education, Stanford, CA http://www.smmcta.com/uploads/9/9/4/2/9942134/evaluation_research_stanford_2012.pdf.
- Dee, T & Cohodes, S 2008, 'Out-of-field teaching and student achievement: Evidence from 'Matched-Pairs' comparisons', *Public Finance Review*, vol. 36, pp. 7-32.
- Donaldson, ML & Johnson, SM 2010, 'The Price of Misassignment: The Role of Teaching Assignments in Teach For America Teachers' Exit From Low-Income Schools and the Teaching Profession', *Educational Evaluation and Policy Analysis*, vol. 32, pp. 299-323, <u>http://dx.doi.org/10.3102/0162373710367680</u>.
- du Plessis, A 2017, *Out-of-field teaching practices: What educational leaders need to know*, SensePublishers, Rotterdam, The Netherlands, <u>https://doi.org/10.1007/978-94-6300-953-9</u>.
- Goldhaber, D 2016, 'In schools, teacher quality matters most: Today's research reinforces Coleman's findings', *Education Next*, vol. 16, pp. 56-62, <u>https://www.educationnext.org/in-schools-teacher-quality-matters-most-coleman/</u>.
- Goldhaber, D & Brewer, D 2000, 'Does Teacher Certification Matter? High School Teacher Certification Status and Student Achievement', *Educational Evaluation and Policy Analysis*, vol. 22, pp. 129-145, <u>http://dx.doi.org/10.3102/01623737022002129</u>.
- Hattie, J 2009, Visible learning: A Synthesis of over 800 meta-analyses relating to achievement, Routledge, London.
- Hill, J & Gruber, K 2011, Education and certification qualifications of departmentalized public high school-level teachers of selected subjects: Evidence from the 2007–08 Schools and Staffing Survey, NCES 2011-317, National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education, Washington, DC.
- Hill, J, Stearns, C & Owens, C 2015, Education and certification qualifications of departmentalized public high school-level teachers of selected subjects: Evidence from the 2011–12 Schools and Staffing Survey, NCES 2015-814, National Center for Education Statistics, U.S. Department of Education, Washington, DC.
- Ho, C 2020, *Aspiration & anxiety : Asian migrants and Australian schooling*, Melbourne University Publishing, Carlton, Melbourne.
- Hobbs, L 2013, 'Teaching 'out-of-field' as a boundary-crossing event: Factors shaping teacher identity', *International Journal of Science and Mathematics Education*, vol. 11, pp. 271-297, <u>http://dx.doi.org/10.1007/s10763-012-9333-4</u>.
- Ingersoll, RM & Perda, D 2010, 'Is the Supply of Mathematics and Science Teachers Sufficient?', *American Educational Research Journal*, vol. 47, pp. 563-594, <u>http://dx.doi.org/10.3102/0002831210370711</u>.
- Morton, BA, Hurwitz, MD, Strizek, GA, Peltola, P & Orlofsky, GF 2008, *Education and certification qualifications of departmentalized public high school-level teachers of core subjects: Evidence from the 2003–04 Schools and Staffing Survey*, National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education, Washington, DC.

- OECD 2005, *Teachers matter: Attracting, developing and retaining effective teachers*, OECD Publishing, Paris, viewed 19 October 2022.
- OECD 2012, Preparing Teachers and Developing School Leaders for the 21st Century, OECD, Paris, viewed 24 April 2019, https://www.oecd-ilibrary.org/content/publication/9789264174559-en.
- OECD 2014, Education at a glance 2014: OECD indicators, OECD Publishing, Paris.
- OECD 2017, PISA 2015 Technical Report, OECD, Paris.
- Office of the Chief Scientist 2014, *Science, technology, engineering and mathematics: Australia's future*, Australian Government, Canberra, viewed 25 April 2019, https://www.chiefscientist.gov.au/wp-content/uploads/STEM_AustraliasFuture_Sept2014_Web.pdf.
- Productivity Commission 2012, *Schools workforce*, Author, Canberra, viewed 25 April 2019, <u>https://www.pc.gov.au/inquiries/completed/education-workforce-schools/report/schools-workforce.pdf</u>.
- Queensland Audit Office 2013, Supply of specialist subject teachers in secondary schools, Report to Parliament 2 : 2013–14, Author, Brisbane.
- Seastrom, MM, Gruber, KJ, Henke, R, McGrath, D & Cohen, BA 2004, *Qualifications of the public school teacher workforce: Prevalence of out-of-field teaching, 1987–88 to 1999–2000*, NCES 2002–603 Revised, National Center for Education Statistics, U.S. Dept. of Education, Washington, DC.
- Shah, C, Richardson, P & Watt, H 2020, *Teaching 'out of field' in STEM subjects in Australia: Evidence from PISA 2015*, GLO Discussion Paper, No. 511 [rev.], Global Labor Organization, Essen <u>http://hdl.handle.net/10419/217484</u>.
- Shah, C, Richardson, PW, Watt, HMG & Rice, S 2022, "Out-of-Field' Teaching in Mathematics: Australian Evidence from PISA 2015', pp. 71-96, in L Hobbs & R Porsch (eds), *Out-of-Field Teaching Across Teaching Disciplines and Contexts*, Springer Nature Singapore, Singapore <u>https://doi.org/10.1007/978-981-16-9328-1_4</u>.
- Shah, L, Jannuzzo, C, Hassan, T, Gadidov, B, Ray, HE & Rushton, GT 2019, 'Diagnosing the current state of out-of-field teaching in high school science and mathematics', *PLOS ONE*, vol. 14, p. e0223186, <u>http://dx.doi.org/10.1371/journal.pone.0223186</u>.
- Sharplin, ED 2014, 'Reconceptualising out-of-field teaching: experiences of rural teachers in Western Australia', *Educational Research*, vol. 56, pp. 97-110, http://dx.doi.org/10.1080/00131881.2013.874160.
- Shulman, LS 1986, 'Those who understand: Knowledge growth in teaching', *Educational Researcher*, vol. 15, pp. 4-14, <u>http://dx.doi.org/10.3102/0013189x015002004</u>.
- Smith, A 2017, *Report of Professor Sir Adrian Smith's review of post-16 mathematics*, Department for Education, London, viewed 25 April 2019, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/630488/AS_review_report.pdf.
- The Royal Society 2007, *The UK's science and mathematics teaching workforce*, A 'state of the nation' report (Chair: Dame Julia Higgins), Author, London, viewed 24 April 2019, https://royalsociety.org/~/media/Royal_Society_Content/Education/policy/state-of-nation/SNR1_full_report.pdf.
- Thomson, S 2021, 'Australia: PISA Australia—excellence and equity?', pp. 25-47, in N Crato (ed) *Improving a country's education: PISA 2018 results in 10 countries*, Springer International Publishing, Cham <u>https://doi.org/10.1007/978-3-030-59031-4_2</u>.
- Weldon, P 2016, Out-of-field teaching in Australian secondary schools, ACER, Melbourne, viewed 25 April 2019, <u>https://research.acer.edu.au/cgi/viewcontent.cgi?article=1005&context=policyinsights</u>.