Gender and VCE Mathematics Subject Enrolments 2001-2015 in Co-Educational and Single-Sex Schools

Helen Forgasz
Monash University
Helen.Forgasz@monash.edu

Gilah Leder
Monash University
Gilah.Leder@monash.edu

Declining enrolments in advanced level mathematics at the school level are noted with concern. Whether school type (single-sex school or co-education) affects participation in mathematics continues to be debated. In this article we examine, by school type and gender, statistical data from 2001 to 2015 on Victorian Certificate of Education enrolments in the three mathematics subjects offered at that level. Also explored are the choice of, and reasons for, the school setting assumed to promote STEM studies for girls and boys.

Introduction

The debate on the relative merits of single-sex and co-educational schooling for girls and for boys persists in Australia. Passionate protagonists are found on both sides. Whether the context is academic achievement, leadership opportunities, or confidence development, one of the most pervasive views put forward is that single-sex schooling is better for girls, while co-education is better for boys.

As in the past (see Ainley & Daly, 2002), the reality in contemporary Australia is that there are more single-sex schools for girls than for boys. This pattern is more marked in some states than in others (see Figure 1), and in the ACT, the opposite is found. One consequence of having more single-sex schools for girls than for boys is that girls are outnumbered by boys in co-educational schools.

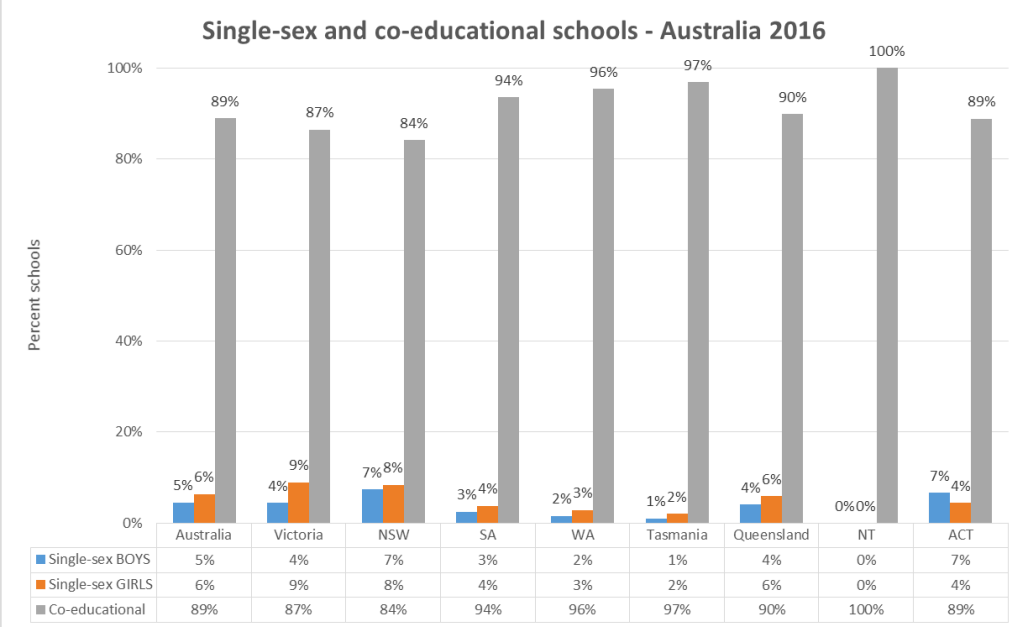


Figure. 1. Percentages of single-sex (boys/girls) and co-educational schools in Australia in 2016, by state/territory. [Data derived from https://www.goodschools.com.au/.]

(2017). In A. Downton, S. Livy, & J. Hall (Eds.), *40 years on: We are still learning! Proceedings of the 40th Annual Conference of the Mathematics Education Research Group of Australasia* (pp. 253-260). Melbourne: MERGA.

Single-sex schooling in Australia is predominantly found in the fee-paying sectors of education (Good Schools Guide, 2016). Within the government sector, single-sex schools generally have selective entry, based on academic achievement. While there are some academic scholarships offered in fee-paying schools, those attending them are generally from higher socio-economic backgrounds than students attending government schools.

That school and family backgrounds are major contributing factors to student achievement is widely accepted (e.g., Hattie, 2009). Cobbold (2015) maintained that in Australia, and elsewhere, "school SES has a much larger impact on student achievement than individual family SES" (pp. 4-5). Student prior achievement and confidence levels, expectations of those in the social milieu, and school factors including teachers and subject offerings all contribute to subject choice decisions (e.g., Eccles et al., 1983; Hattie, 2009).

Declining enrolments in advanced level mathematics at the school level (e.g., Barrington & Evans, 2014) and the under-representation of females in these subjects (e.g., Barrington & Evans, 2014; Finkel & Sherry, 2017) continue to be of concern. Forgasz (2016) noted the frequency of claims, and strength of beliefs, that girls attending single-sex schools are more likely than girls in co-educational schools to study mathematics and science subjects. But where is the statistical evidence to support these claims?

In this article, we present statistical data from 2001 to 2015 on Victorian Certificate of Education (VCE) enrolments in the three mathematics subjects offered (specialist mathematics, mathematical methods, and further mathematics) by gender and school type (single sex girls, single-sex boys, co-educational girls, and co-educational boys) obtained from the Victorian Curriculum and Assessment Authority (VCAA).

Our aims in examining the VCE mathematics enrolment data, 2001-2015, were to examine enrolment patterns over time for girls and for boys attending single-sex and co-educational schools, and to determine whether girls and/or boys are more likely to study these subjects if they attend single-sex schools. In addition, to tap current views in Australia about the suitability of single-sex schools for girls and boys to study science, technology, engineering and mathematics (STEM) subjects, we draw on survey data from a larger study about schooling, careers, and STEM pathways.

Previous Research in the Field

Research has been conducted to compare the mathematics achievement of males and females attending single-sex and co-educational schools; attitudes and beliefs have also been investigated. Thien and Darmawan (2016) reported that in 12 countries participating in the first international study of mathematics, "the greater the ratio of single sex to co-educational schools the greater the difference between the sexes in Mathematics Performance, with boys outperforming girls at the 13-year old level" (p. 89).

Lenzer (2006) noted the contradictory findings with respect to girls' mathematics and science achievement and participation in single-sex and co-educational schools. In some studies girls attending single-sex schools, compared to girls in co-educational schools, "are more likely to have confidence or be interested in mathematics and to choose mathematics and or natural sciences as a subject of study later on" (p. 58). But she also reported that "[W]hen students entering single-sex or co-educational schools are matched for background variables, the effect of gender-segregated education on non-traditional subject choice… disappears" (p. 58). Billinger (2008) surveyed single-sex schooling within the US and similarly concluded that the "apparent benefits of single-sex schooling can largely be attributed to selection bias in the pool of students who choose SSE" (p. 402). Thus, school culture appears to be a critical factor implicated in girls' non-traditional subject choice.

The effects of single-sex classes within co-educational secondary schools have also been explored. Leder & Forgasz (1998) reported mixed results on students', teachers', and parents' attitudes to the introduction of single-sex mathematics classes at grade 9 in one Australian co-educational school. "Single-sex classes *per se",* they concluded, "would appear to be too simplistic a strategy to address identified gender inequities in mathematics education" (p. 177). Writing about single-sex classes in the middle years of schooling, Crosswell and Hunter (2012) concluded that "there is no 'right' answer due to the multiple variables that could be playing out in any classpace" (p. 25), and that underpinning "the seemingly simple question of single sex classes in co-education schools, is the much more complex socio-political issue of assumptions about sex and gender" (p. 25).

Australian research on participation in mathematics subjects in co-educational and single-sex schools is scarce. Some work has been conducted internationally, and there are some Australian findings related to STEM participation more generally, and in the physical sciences. Ainley and Daly (2002) reported raw data on physical science participation in single-sex and co-educational schools in Australia in 1998. They found that girls attending single-sex schools were more likely than girls in co-education schools to study these subjects. However, when a multivariate analysis was conducted, this "apparently greater participation… was not statistically significant after allowance was made for other influences that were associated with school gender context" (p. 256). The factors involved in the multivariate analysis included: language background, socio-economic status, earlier school achievement, residential location, and school type.

In summary, the literature is mixed about the benefits of single-sex schooling (or classes) for girls and their achievement and attitudes towards mathematics. Little appears to be known about girls', compared to boys', relative enrolments in senior level mathematics in Australia, nor about females' views and recommendations of school type for boys or girls interested in STEM-related subjects. In this study, we address these issues.

The Study

Methods

The VCAA data. In response to a request to the VCAA, VCE enrolment data for the years 2001-2015 for specialist mathematics, mathematical methods (CAS), and further mathematics, were provided by gender within school type (single-sex and co-educational); permission was denied for a further break-down of the data by school sector (government, Catholic, and independent). Also provided were the number of students within each school type by gender who were eligible to complete VCE in each year, allowing for the proportions of students enrolled in these subjects by gender within school type to be calculated. Analyses of VCE data by gender within school type are unique; the VCAA had not previously been requested to provide data of this kind (Bui, personal communication).

In consultation with VCAA, it was determined that the most effective enrolment comparisons would result from comparing the percentages of students eligible to complete VCE who were enrolled in each subject, that is, not to include students who were studying the subjects as part of their year 11 of the two-year VCE.

For each year, 2001 to 2015, the percentages of students eligible to complete VCE enrolled in each subject were calculated for boys and for girls in single sex and in co-educational schools. These percentages are shown in Figures 2-4 below for each of the three mathematics subjects.

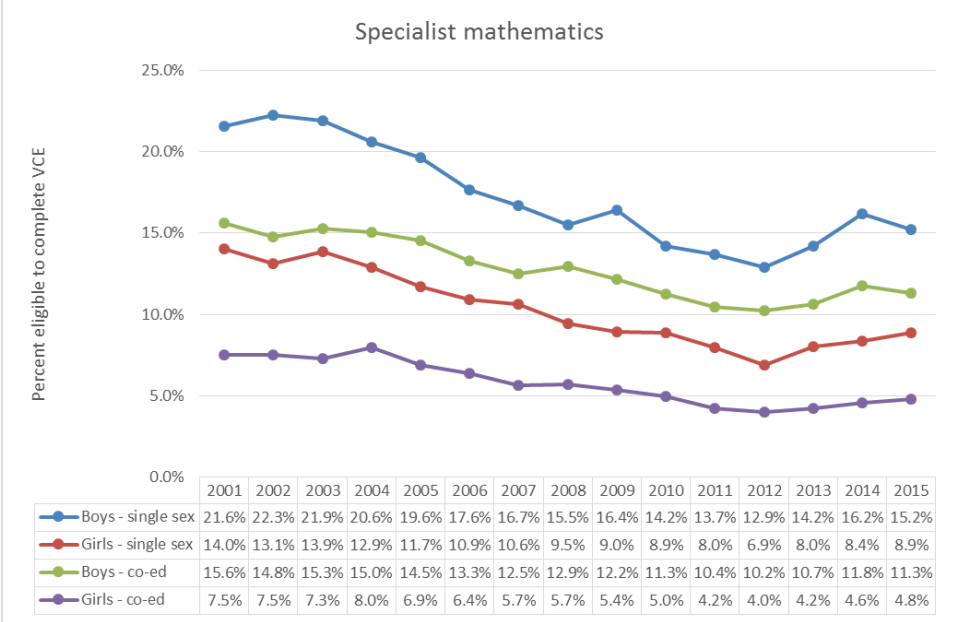
The survey data. The items in which survey participants were asked whether, to promote a boy's/girl's interest in STEM-related studies, they would recommend a single-sex school, a co-educational school, or neither (that it would depend on the child), were of particular interest for this article. Also of interest were the explanations provided for the choices nominated by the respondents.

Results

The VCAA data. Trends in the data for each mathematics subject (see Figures 2 to 4) were examined, and the enrolment pattern findings for each subject are reported below.

Specialist mathematics. The data in Figure 2 reveal that:

- Higher proportions of boys in both single-sex and in co-educational schools study specialist mathematics than girls in single-sex or co-educational schools (that is, boys dominate over girls irrespective of school type).
- The difference in the proportions of boys and girls studying specialist mathematics is about the same in each school type
- A higher proportion of girls in single-sex schools than in co-educational schools study specialist mathematics; the same pattern is evident among the boys.
- Over time, there was a steady decrease in the proportions of boys and girls in both school types studying specialist mathematics until 2012, after which increases for girls in both school types, and inconsistencies among boys in both school types, are evident.



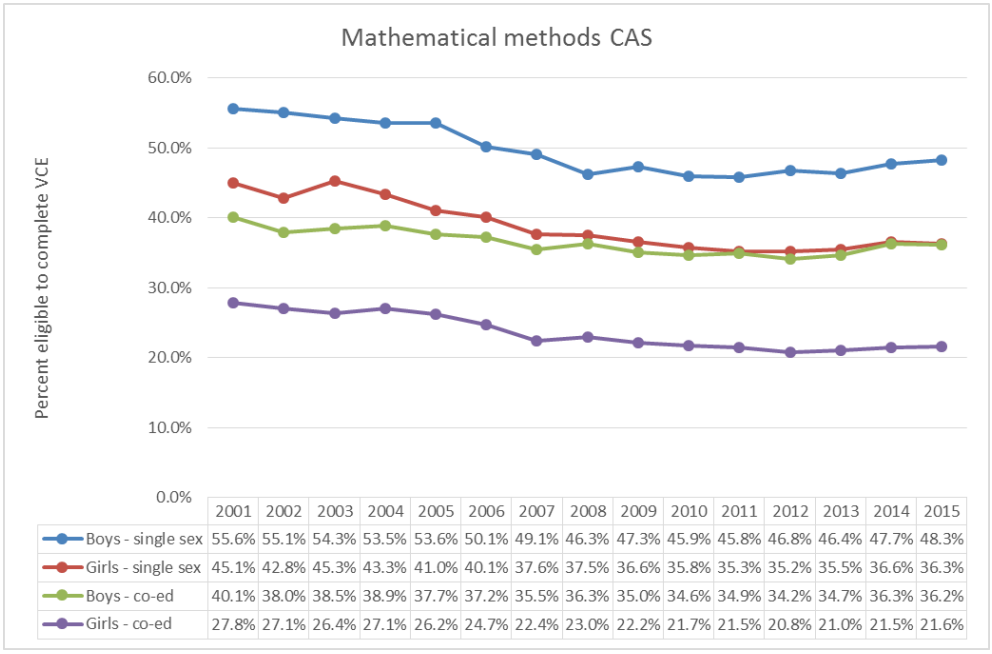
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Boys - single sex	21.6%	22.3%	21.9%	20.6%	19.6%	17.6%	16.7%	15.5%	16.4%	14.2%	13.7%	12.9%	14.2%	16.2%	15.2%
Girls - single sex	14.0%	13.1%	13.9%	12.9%	11.7%	10.9%	10.6%	9.5%	9.0%	8.9%	8.0%	6.9%	8.0%	8.4%	8.9%
Boys - co-ed	15.6%	14.8%	15.3%	15.0%	14.5%	13.3%	12.5%	12.9%	12.2%	11.3%	10.4%	10.2%	10.7%	11.8%	11.3%
Girls - co-ed	7.5%	7.5%	7.3%	8.0%	6.9%	6.4%	5.7%	5.7%	5.4%	5.0%	4.2%	4.0%	4.2%	4.6%	4.8%

Figure. 2. Percentages of girls and boys eligible to complete VCE in single-sex and co-educational schools enrolled in specialist mathematics, 2001-2015.

Mathematical methods (CAS). The data in Figure 3 reveal that:

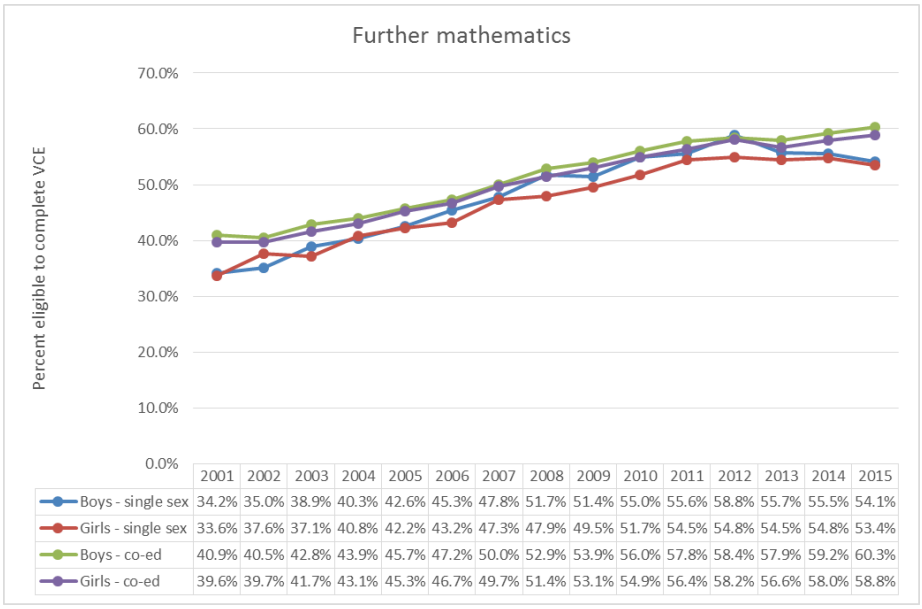
- A higher proportion of girls in single-sex schools than in co-educational schools study mathematical methods; the same pattern is evident among the boys.
- Higher proportions of students (both boys and girls) in single sex schools than in co-educational schools study mathematical methods (CAS)

- Over time, there has been a steady decrease in the proportions of boys and of girls in both school types studying mathematical methods (CAS); interestingly the decreases have been greater for girls in both schools types (single-sex: 8.8%; co-educational: 6.2%) than for boys (single-sex: 7.3%; co-educational: 3.9%), and greater in single-sex schools for both girls and boys than for boys and girls in co-educational schools.



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Boys - single sex	55.6%	55.1%	54.3%	53.5%	53.6%	50.1%	49.1%	46.3%	47.3%	45.9%	45.8%	46.8%	46.4%	47.7%	48.3%
Girls - single sex	45.1%	42.8%	45.3%	43.3%	41.0%	40.1%	37.6%	37.5%	36.6%	35.8%	35.3%	35.2%	35.5%	36.6%	36.3%
Boys - co-ed	40.1%	38.0%	38.5%	38.9%	37.7%	37.2%	35.5%	36.3%	35.0%	34.6%	34.9%	34.2%	34.7%	36.3%	36.2%
Girls - co-ed	27.8%	27.1%	26.4%	27.1%	26.2%	24.7%	22.4%	23.0%	22.2%	21.7%	21.5%	20.8%	21.0%	21.5%	21.6%

Figure. 3. Percentages of girls and boys eligible to complete VCE in single-sex and co-educational schools enrolled in mathematical methods (CAS), 2001-2015.



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Boys - single sex	34.2%	35.0%	38.9%	40.3%	42.6%	45.3%	47.8%	51.7%	51.4%	55.0%	55.6%	58.8%	55.7%	55.5%	54.1%
Girls - single sex	33.6%	37.6%	37.1%	40.8%	42.2%	43.2%	47.3%	47.9%	49.5%	51.7%	54.5%	54.8%	54.5%	54.8%	53.4%
Boys - co-ed	40.9%	40.5%	42.8%	43.9%	45.7%	47.2%	50.0%	52.9%	53.9%	56.0%	57.8%	58.4%	57.9%	59.2%	60.3%
Girls - co-ed	39.6%	39.7%	41.7%	43.1%	45.3%	46.7%	49.7%	51.4%	53.1%	54.9%	56.4%	58.2%	56.6%	58.0%	58.8%

Figure. 4. Percentages of girls and boys eligible to complete VCE in single-sex and co-educational schools enrolled in further mathematics, 2001-2015.

Further mathematics. The data in Figure 4 reveal:

- Similar patterns of enrolments in further mathematics for boys and for girls in both school types
- Over time, the proportions of boys and girls in both school types enrolled in further mathematics have increased at very similar rates.

The survey data. The survey sample comprised over 1,100 females, aged from 18 to over 70. Most had studied mathematics in their final year of secondary school: advanced level ($N = 377$), intermediate level ($N = 472$), and elementary level ($N = 126$) mathematics; some ($N = 89$) had not studied any mathematics. Consistent with the focus of the larger study on single-sex schools, the majority of respondents ($N = 964$) had attended a single-sex school and a smaller number ($N = 164$) a co-educational school.

As can be seen from the data in Table 1, almost half of the female respondents thought that a single-sex school setting would promote STEM-related studies for girls, compared with 14% who thought this was the case for boys.

Table 1
School Setting Thought to Promote STEM-Related Studies

Recommendation	For boys	For girls
Single-sex school	138 (14%)	427 (43%)
Co-educational school	98 (10%)	79 (8%)
Either, depends on child	739 (76%)	485 (49%)
Total	975	991

Whether the type of school the respondents themselves attended seemed to influence the school setting they nominated can be gauged from the data in Table 2.

Table 2
Recommendation of School Setting by Respondents' Own Schooling

	Recommendation	Attended co-educational school	Attended single-sex school
To promote a boy's interest	single-sex school	10 (7%)	128 (16%)
	co-educational school	32 (22%)	66 (8%)
	either, depends on child	107 (72%)	632 (77%)
To promote a girl's interest	single-sex school	27 (18%)	400 (48%)
	co-educational school	35 (24%)	44 (5%)
	either, depends on child	87 (58%)	398 (47%)

It can be seen in Table 2 that a higher proportion of those who attended a single-sex school considered single-sex schools (16%) as more suitable than co-educational schools (8%) to promote a boy's interest in STEM-related studies, while a higher proportion of those who attended a co-educational school thought boys would benefit from attendance at co-educational schools (22%) than single-sex schools (7%). The differences in the settings nominated were statistically significant ($\chi^2 = 30.09$, $p<.001$, effect size, $V=.18$).

A comparable pattern can be seen in Table 2 for promoting girls' interest in STEM. Of those who attended single-sex schools, a higher proportion nominated single-sex schools 48%) than co-educational schools (5%) to promote girls' interest in STEM. Of those who

had attended co-educational schools, a higher proportion recommended co-educational schools (24%) than single-sex schools (18%) to promote girls' interest in STEM. The different patterns nominated were statistically significant (χ^2 = 81.55, p<.001, effect size, V=.29). Also noteworthy are the smaller proportions of those attending single-sex and co-educational schools who nominated "could be either" for girls (47% and 58% respectively) than for boys (77% and 72% respectively).

As indicated earlier in the paper, respondents were also asked to provide the reason(s) for their choice of school setting to promote STEM interest for girls and for boys. The explanations of those whose recommendation for boys and girls differed were of particular interest. Space constraints allow only a small but representative set to be included here.

To promote a BOY'S interest in STEM	To promote a GIRL's interest in STEM and
Attended single-sex school; advanced and intermediate maths in final year of school	
Either, depends on child	*Single-sex school*
Boys are seen as more naturally gravitating towards these subjects. In fact, although I am pronouncing on matters about which I know next to nothing, I would have thought that a boy in a single sex school might have more difficulty pursuing humanities. Whether the child is in a single sex school or a co-ed school (and therefore, perhaps, opinions of their peers about their choice of subjects) probably has much less significance from a gender perspective.	Girls are rarely told these days (I hope) that 'girls don't do that', but that doesn't mean that the subtle societal messages don't do a damn good job of making sure girls 'know' that STEM subjects are not feminine, and what's more, that femininity as defined by society is an overarching goal. I recall being encouraged at a single sex school to take STEM subjects because I was smart, and good at them, and perhaps I felt that I should take them in case I needed them.
Attended single-sex school; advanced and intermediate maths in final year of school	
Co-educational school	*Single-sex school*
Look at industry - males don't seem to need any consideration here - system seems to be working for men in STEM.	I think girls benefit from a single sex schooling system where they are given the tools and ideological foundation to believe they can achieve anything - before having to identify with the gender bias and inequalities that exist in STEM.
Attended single-sex school; advanced and intermediate maths in final year of school	
Either, depends on child	*Single-sex school*
Boys don't get told they are not good at maths or science so I think choice of school is not as important	Peer pressure and gender stereotypes are more likely to arise at a co-ed school
Attended co-educational school; intermediate mathematics in final year of school	
Either, depends on child	*Single-sex school*
Each child learns differently and is to be nurtured for their individual learning style	Girls I have observed in 15 years plus teaching are more confident and driven in a single sex setting

Summary of Findings

Higher proportions of boys in single-sex and in co-educational schools than girls in single-sex and in co-educational schools are enrolled in specialist mathematics. While for

specialist mathematics there was a higher proportion of girls from single-sex than co-educational schools enrolled, the same was true among boys in the two school types. Higher proportions of girls and boys in single-sex schools than in co-educational schools were enrolled in mathematical methods CAS. The proportions of students enrolled in further mathematics is virtually identical among boys and girls in single-sex and co-educational schools.

It is too simplistic to conclude that the gendered setting of the school alone contributes to the differences found, particularly considering that the same proportions of boys and girls in both school types were enrolled in further mathematics. Yet from the explanations provided for the preference expressed for a single-sex or co-educational school to promote STEM-related subjects it can be seen that respondents were influenced by their own school history and that, among this group of generally well-educated females, the belief that girls more often than not benefit from attendance at a single-sex school persists.

Acknowledgments

This study was partially funded by the Alliance of Girls Schools in Australasia. We thank Natalie Kalkhoven and Simone Zmood, who assisted in the data analyses.

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