Single-sex versus co-educational schooling and STEM pathways: Final report

FOR: Alliance of Girls' Schools Australasia

Monash University, October 2017

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Introduction

In Australia, the debate on the relative merits of single-sex and co-educational schooling for girls and for boys persists. 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, particularly with respect to pursuing STEM-related studies. In this report, we present findings of a recent investigation for which the initial aims were:

1. to compare STEM participation rates at school level and beyond for females who attended single-sex and co-educational schools, in different time periods (e.g., by decade), by school type attended (government and non-government), and by country (Australia and New Zealand);
2. to identify and compare the life/career trajectories of these females;
3. to identify systemic and/or personal factors facilitating or inhibiting STEM participation of these females; and
4. to compare the above with responses from a male sample

We added a fifth aim:

5. to explore perceptions of single-sex or co-educational schooling to promote STEM for girls and boys.

Data for the study were gathered using an online survey. To recruit participants, Facebook advertising was used and invitations to participate were distributed to alumnae of member schools of the Alliance of Girls' Schools Australasia.

Caveats

1. Sample exclusions
   a. New Zealand participants

   Early into the study, we found that response rates from New Zealand were very low. While many New Zealanders looked at the online survey, very few completed the survey. Since costs associated with Facebook advertising are based on the number of clicks on the advertisement, it was quickly realised that the limited budget precluded the continuation of targeting New Zealand participants. Thus, the focus turned to Australian participants only with subsequent changes to the layout and design of the Facebook advertisements[1], and comparisons by country could not be undertaken.

   b. Non-binary (gender)

   As has now become routine, gender options included "non-binary". The respondents who identified as "non-binary" were excluded from analyses as numbers were small (2).

2. Small male sample.

   The response rate of male participants from Facebook advertising was low. Since boys' schools are not members of the Alliance, recruitment was limited to Facebook advertising, thus further

[1] Examples of the various Facebook advertisements used are included in Appendix A.

restricting the final male sample. We spent additional monies (outside the budget of the study) to try to boost the male response rate; this required further changes to the layout and design of the Facebook advertisement. We were partially successful. Since, however, within our timeline we received fewer than 10 responses from males who had attended single-sex schools, the analyses we report are restricted to comparisons between the full samples of females and males.

3. Additional data.

   In order to validate that our sample of respondents was from those focussing on STEM studies and careers, we requested data from the Victorian Curriculum and Assessment Authority (VCAA) to disaggregate Victorian Certificate of Education (VCE) Year 12 enrolment data in STEM subject areas by school type attended (single-sex or co-education) as well as by gender. VCAA did not allow further disaggregation by school sector, as there is only one single-sex boys' school in the government sector in Victoria and the data would not be anonymous. The VCAA data, however, have proven invaluable in establishing the validity of the sample.

4. Small sample of female respondents from single-sex government schools

   The number of female respondents attending single-sex government schools was small compared to the number from non-government (Independent and Catholic) schools. A consequence of this limitation is that we do not report findings by school sector for the female respondents attending single-sex schools.

5. Qualitative data limitations.

   Due to budget limitations, we were unable always to analyse the full set of qualitative responses from female participants from single-sex schools. Since the number of female respondents from co-educational schools was 164, it was decided to consider the responses of a random sample of 164 females from single-sex schools. A random number generator was used to generate the 164 ID numbers from the full sample of 964 single-sex females. In some parts of this report, we do report on the qualitative responses from all single-sex females; for other analyses only the responses from the randomly selected 164 single-sex female responses are reported.

6. Variations in sample totals

   Since not all respondents answered all questions, small variations in sample totals will be found throughout the report.

Contents of this report

In light of the caveats discussed above, in this report we provide findings based on the aims of the study as follows:

- Contextualising the study
  - Data on single-sex schooling in Australia in 2015
  - Victorian VCE enrolments in STEM subjects (2001 to 2015)
- Methods adopted to gather data in the online survey
- Details about the full sample who completed our survey
  - Background information (age, type of school attended, decade school completed)
  - STEM subjects studied at year 12 (by females, males, and 2015 VCE cohort)
- Information about all the females in our sample

    - Attendance at single-sex (SS) or co-educational (co-ed) school (age, decade school completed, progression to higher education, qualifications completed)
    - STEM subjects studied at year 12 (by age, decade school completed)
- Information about the respondents who attended a SS school
    - STEM subjects studied at year 12 (by age, decade school completed)
    - Progression to higher education, whether or not in employment at the time of survey completion
    - Factors influencing initial career path by decade of school completion
    - Barriers and supports for career pathways and goals
- School choice for promotion of STEM (Female sample: SS and co-ed)
    - Quantitative data and qualitative explanations
- Qualitative data
    - Snapshots derived from the female sample: reduced random SS sample (N=164) and co-ed full sample (N=164)
    - Factors influencing change of career
    - Career barriers and support

Additional information is included in the appendices including:

- Samples of the Facebook advertisements to recruit participants (Appendix A)
- A copy of the online survey used in the study (Appendix B)
- Material related to the various articles and conference papers we have prepared in which we have drawn on data from the study (Appendix C)

Contextualising the study

Single-sex schooling in Australia

As noted in the *Good Schools Guide* (2016), single-sex schooling in Australia is predominantly found in the fee-paying sectors of education; 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 (Australian Bureau of Statistics [ABS], 2006. Research has shown that school and family backgrounds, including socio-economic status, are major contributing factors to student achievement (e.g. Cobbold, 2015; Hattie, 2009).

In Australia, there are more single-sex schools for girls than for boys. The 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.

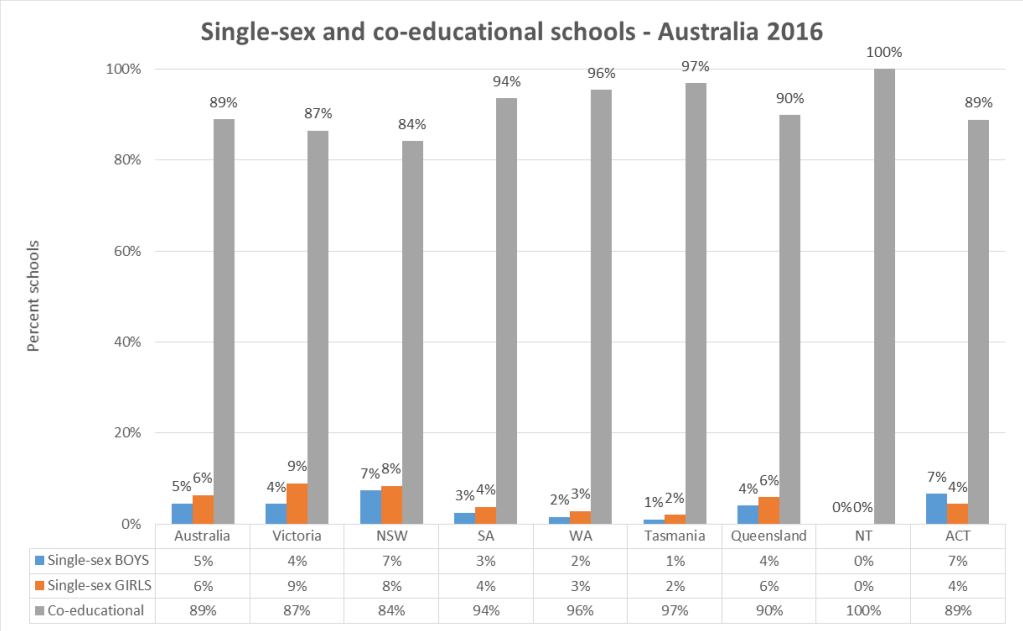


Fig. 1. Percentages of single-sex (boys/girls) and co-educational schools in Australia in 2016, by state/territory. [Data derived from *The Good Schools Guide* (https://www.goodschools.com.au/)]

Currently there are 190 girls' schools in Australia including 34 government girls' schools. Of the remaining 156, approximately half are independent and half are Catholic. Most are located in NSW (40%) and Vic (27%), followed by Qld (16%), SA (7%), WA (5%), Tas (2.6%), and the ACT (1.6%). There are no single-sex schools for girls (or boys) in the Northern Territory (Derived from *Alliance of Girls' Schools Australasia database of girls' schools,* 2017). The 2016 data on girls' schools were similar.

As in many other countries (e.g., OECD, 2017[2]), there are on-going concerns in Australia about

[2] "The career paths of boys and girls already start to diverge by the age of 15. OECD-wide, 15-year-old boys are, on average, more than twice as likely as girls to expect to work as engineers, scientists or architects. And while less than 0.5% of girls wish to be ICT professionals, almost 5% of boys do" (OECD, 2017, p.105).

declining enrolments in the STEM (science, technology, engineering, and mathematics) disciplines at the tertiary and school levels (e.g., Roberts, 2014), and the under-representation of females in many of these fields and in many STEM-related occupations (e.g., Finkel, 2016; Professionals Australia, n. d.). Claims are frequently made that girls attending single-sex schools are more likely than girls in co-educational schools to study science and mathematics subjects.

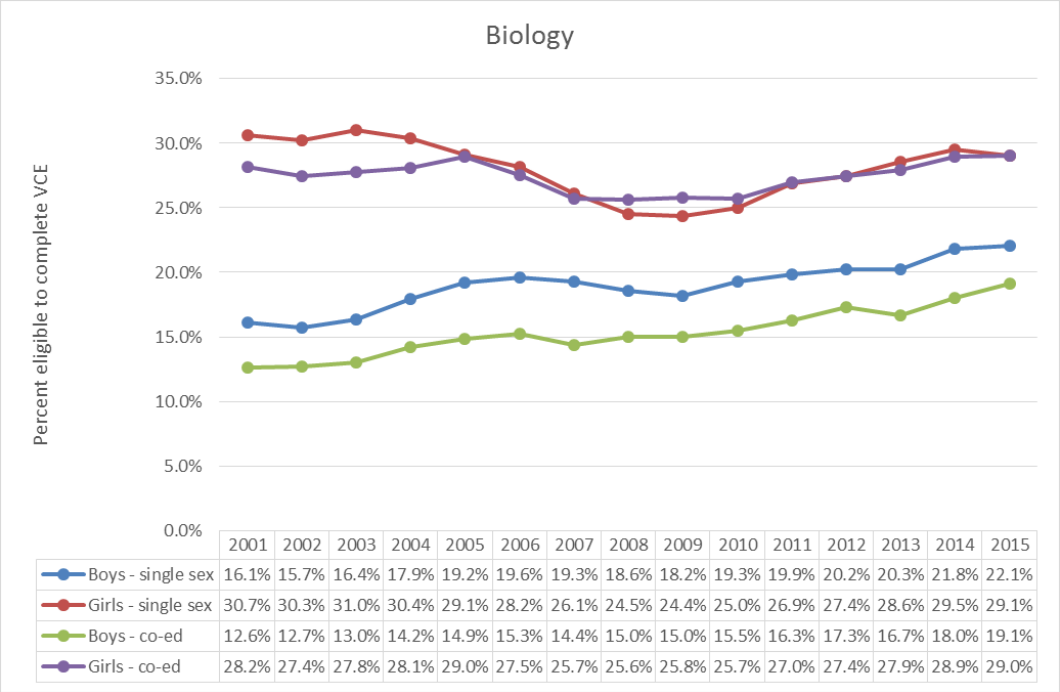
Enrolments in STEM subjects in the final year of the Victorian Certificate of Education (VCE), 2015

In response to a request to the Victorian Curriculum and Assessment Authority (VCAA), VCE enrolment data for the years 2001-2015 for all STEM subjects (biology, chemistry, physics, further mathematics, mathematical methods (CAS), specialist mathematics, IT applications, and software development) 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 data on the numbers of students within each school type by gender who were eligible to complete VCE in each year.

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. 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 2-8 below for each STEM subject.

The enrolment pattern findings for each subject are reported in turn.

Biology



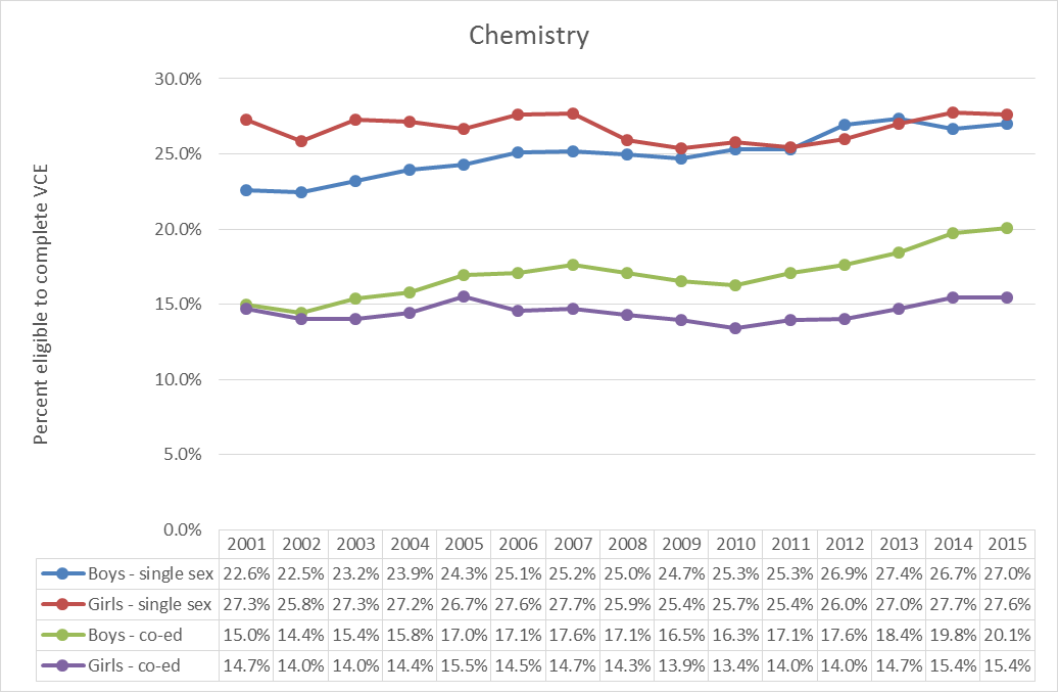
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Boys - single sex	16.1%	15.7%	16.4%	17.9%	19.2%	19.6%	19.3%	18.6%	18.2%	19.3%	19.9%	20.2%	20.3%	21.8%	22.1%
Girls - single sex	30.7%	30.3%	31.0%	30.4%	29.1%	28.2%	26.1%	24.5%	24.4%	25.0%	26.9%	27.4%	28.6%	29.5%	29.1%
Boys - co-ed	12.6%	12.7%	13.0%	14.2%	14.9%	15.3%	14.4%	15.0%	15.0%	15.5%	16.3%	17.3%	16.7%	18.0%	19.1%
Girls - co-ed	28.2%	27.4%	27.8%	28.1%	29.0%	27.5%	25.7%	25.6%	25.8%	25.7%	27.0%	27.4%	27.9%	28.9%	29.0%

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

The data in Figure 2 reveal that:

- A similar proportion of girls in single-sex and in co-educational schools study biology
- A higher proportion of boys in single-sex schools than in co-educational schools study biology
- Over time, the proportions of boys in both schools types who study biology have increased steadily; for girls in both school types there was a decline until 2009 and then the numbers have been increasing again.

Chemistry



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Boys - single sex	22.6%	22.5%	23.2%	23.9%	24.3%	25.1%	25.2%	25.0%	24.7%	25.3%	25.3%	26.9%	27.4%	26.7%	27.0%
Girls - single sex	27.3%	25.8%	27.3%	27.2%	26.7%	27.6%	27.7%	25.9%	25.4%	25.7%	25.4%	26.0%	27.0%	27.7%	27.6%
Boys - co-ed	15.0%	14.4%	15.4%	15.8%	17.0%	17.1%	17.6%	17.1%	16.5%	16.3%	17.1%	17.6%	18.4%	19.8%	20.1%
Girls - co-ed	14.7%	14.0%	14.0%	14.4%	15.5%	14.5%	14.7%	14.3%	13.9%	13.4%	14.0%	14.0%	14.7%	15.4%	15.4%

Fig. 3. Percentages of girls and boys eligible to complete VCE in single-sex and co-educational schools enrolled in chemistry, 2001-2015.

The data in Figure 3 reveal that:

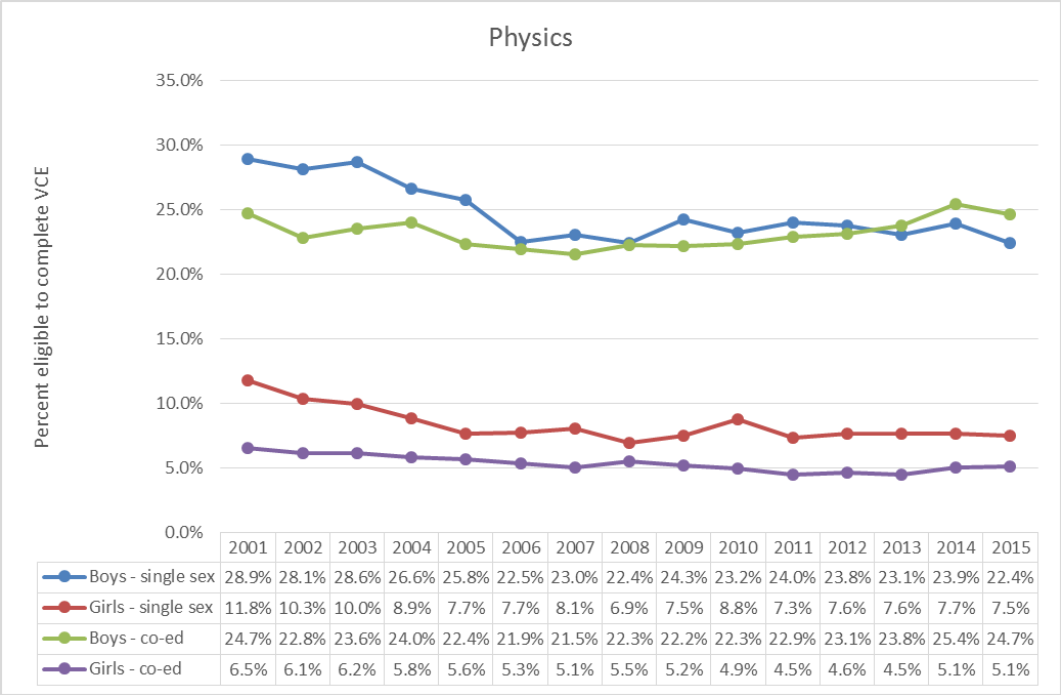
- A higher proportion of girls in single-sex schools than in co-educational schools study chemistry; the same pattern is evident among the boys.
- Over time, the proportions of girls in single-sex and in co-educational schools studying chemistry has remained steady; for boys in both school types the proportions studying chemistry have steadily increased.

Physics

The data in Figure 4 reveal that:

- Much higher proportions of boys than girls in both school types study physics
- Over time, the proportions of boys in co-educational schools studying physics has remained steady, while the proportions of boys in single-sex schools studying physics has steadily decreased.

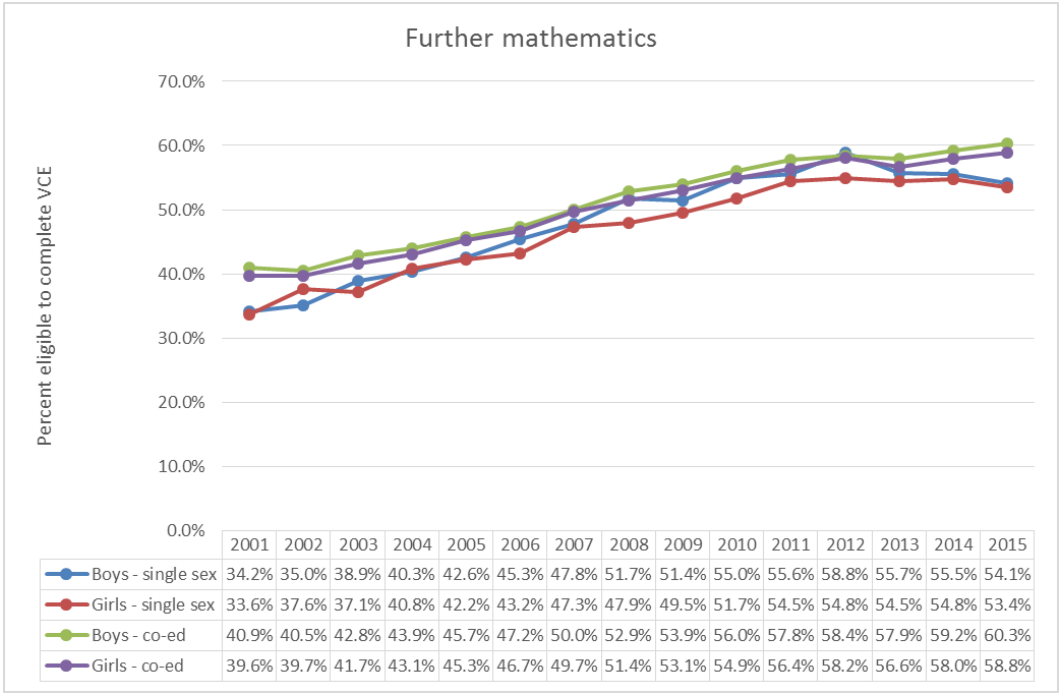
- While slightly higher proportions of girls in single-sex schools than in co-educational schools study physics, there has been a decrease in proportions of girls in both school types, with the decrease greater in single-sex schools.



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Boys - single sex	28.9%	28.1%	28.6%	26.6%	25.8%	22.5%	23.0%	22.4%	24.3%	23.2%	24.0%	23.8%	23.1%	23.9%	22.4%
Girls - single sex	11.8%	10.3%	10.0%	8.9%	7.7%	7.7%	8.1%	6.9%	7.5%	8.8%	7.3%	7.6%	7.6%	7.7%	7.5%
Boys - co-ed	24.7%	22.8%	23.6%	24.0%	22.4%	21.9%	21.5%	22.3%	22.2%	22.3%	22.9%	23.1%	23.8%	25.4%	24.7%
Girls - co-ed	6.5%	6.1%	6.2%	5.8%	5.6%	5.3%	5.1%	5.5%	5.2%	4.9%	4.5%	4.6%	4.5%	5.1%	5.1%

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

Further mathematics



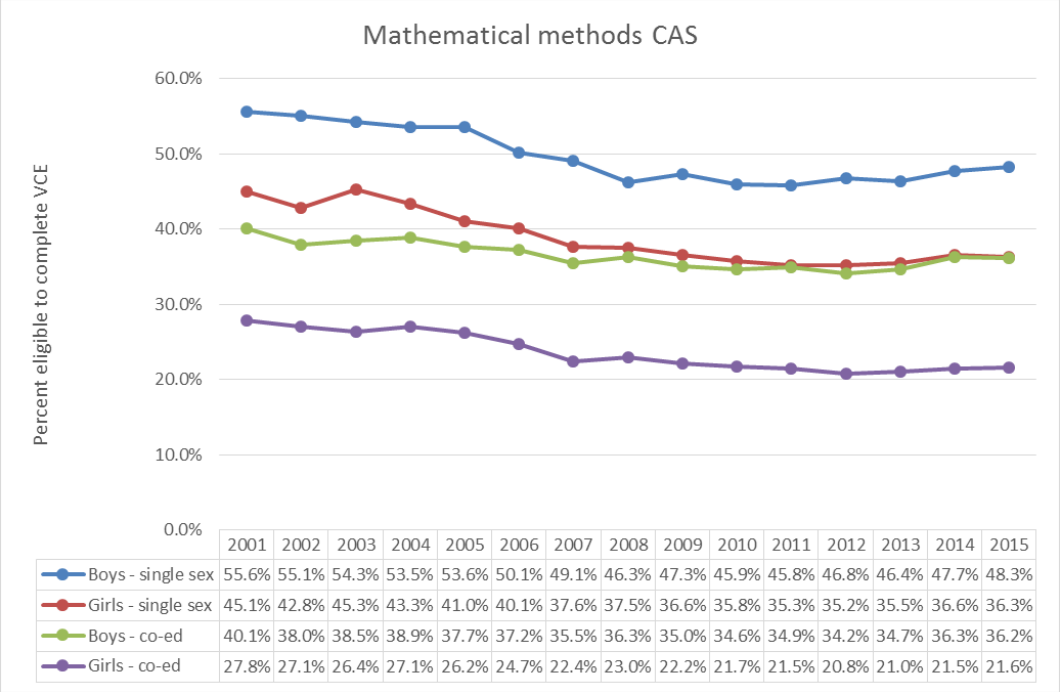
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Boys - single sex	34.2%	35.0%	38.9%	40.3%	42.6%	45.3%	47.8%	51.7%	51.4%	55.0%	55.6%	58.8%	55.7%	55.5%	54.1%
Girls - single sex	33.6%	37.6%	37.1%	40.8%	42.2%	43.2%	47.3%	47.9%	49.5%	51.7%	54.5%	54.8%	54.5%	54.8%	53.4%
Boys - co-ed	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%

Fig. 5. Percentages of girls and boys eligible to complete VCE in single-sex and co-educational schools enrolled in further mathematics, 2001-2015.

The data in Figure 5 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

Mathematical methods (CAS)



	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%

Fig. 6. Percentages of girls and boys eligible to complete VCE in single-sex and co-educational schools enrolled in mathematical methods (CAS), 2001-2015.

The data in Figure 6 reveal that:

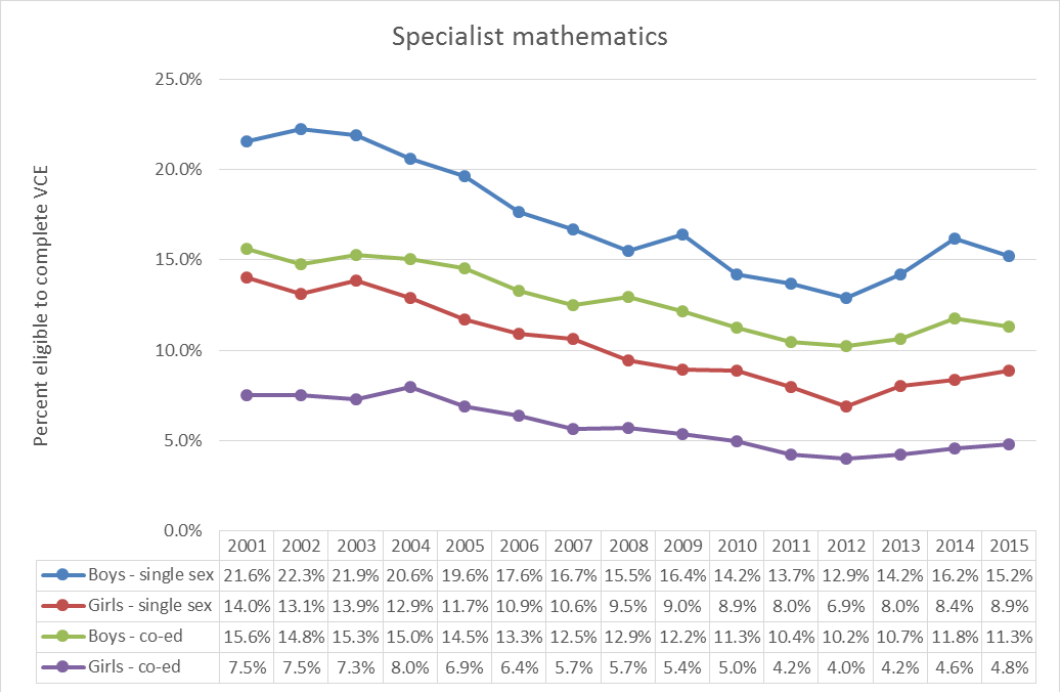
- A higher proportion of girls in single-sex schools than in co-educational schools study mathematical methods; the same pattern is evident among the boys.
- Over time there has been a steady decrease in the proportions of boys and of girls in both school types studying mathematical methods (CAS); interestingly the decreases have been greater for girls in both schools types (s-s: 8.8%; co-ed: 6.2%) than for boys (s-s: 7.1%; co-ed: 3.9%), and greater in single-sex schools for both girls and boys than for boys and girls in co-educational schools.

Specialist mathematics

The data in Figure 7 reveal that:

- 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.
- The difference in proportions of boys and girls in single-sex schools studying specialist mathematics is smaller than the difference in co-educational schools.
- 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

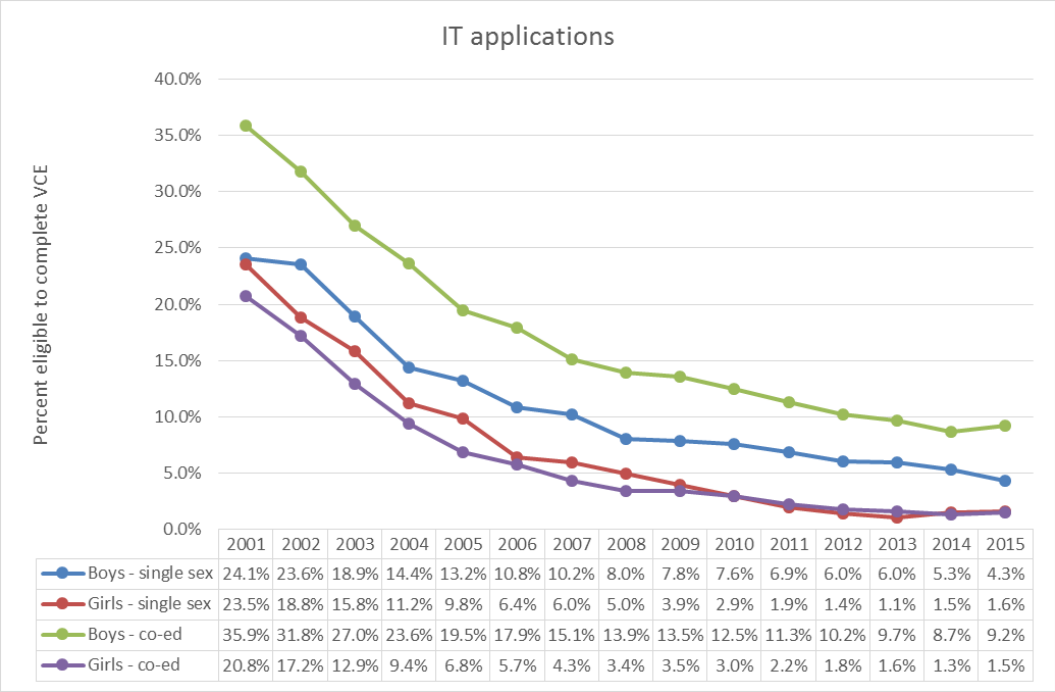
school types and inconsistencies among boys in both school types are evident. The overall decrease between 2001 and 2015 was greater for girls in both school types (approx. 36%) compared to boys in both school types (approx. 27%)



	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%

Fig. 7. Percentages of girls and boys eligible to complete VCE in single-sex and co-educational schools enrolled in specialist mathematics, 2001-2015.

IT applications



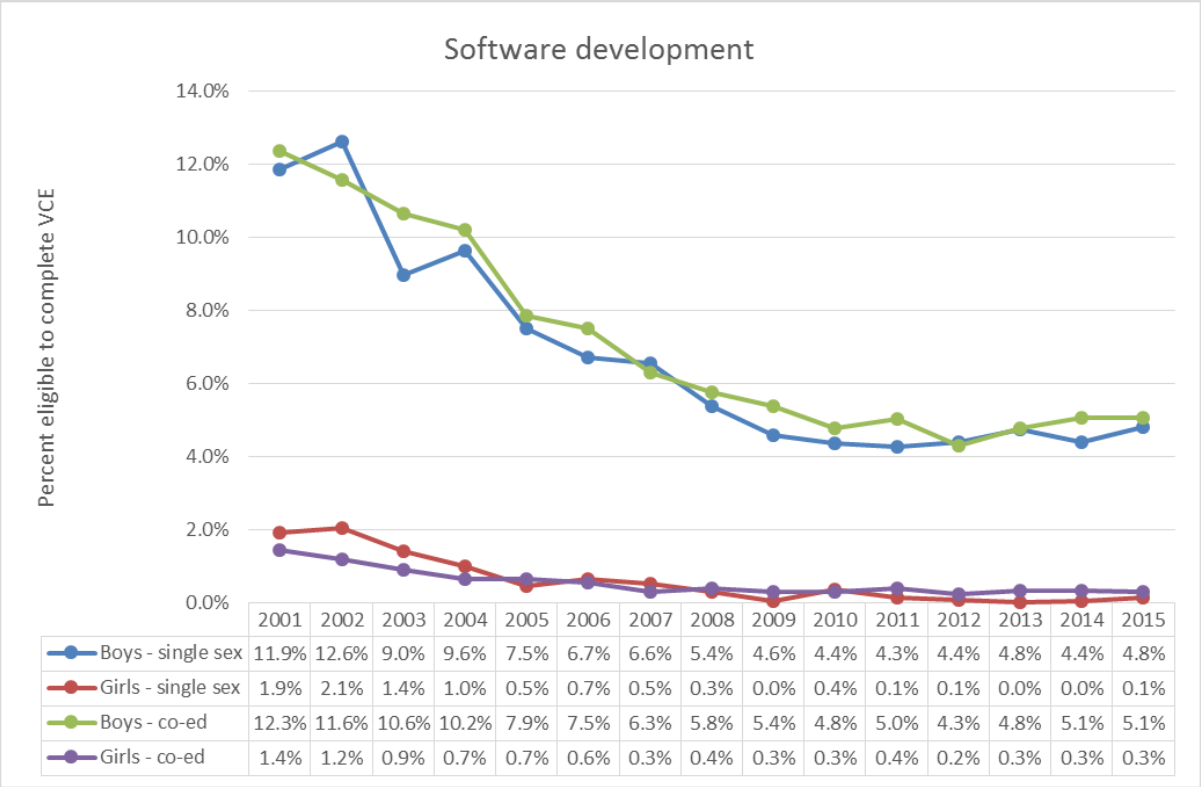
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Boys - single sex	24.1%	23.6%	18.9%	14.4%	13.2%	10.8%	10.2%	8.0%	7.8%	7.6%	6.9%	6.0%	6.0%	5.3%	4.3%
Girls - single sex	23.5%	18.8%	15.8%	11.2%	9.8%	6.4%	6.0%	5.0%	3.9%	2.9%	1.9%	1.4%	1.1%	1.5%	1.6%
Boys - co-ed	35.9%	31.8%	27.0%	23.6%	19.5%	17.9%	15.1%	13.9%	13.5%	12.5%	11.3%	10.2%	9.7%	8.7%	9.2%
Girls - co-ed	20.8%	17.2%	12.9%	9.4%	6.8%	5.7%	4.3%	3.4%	3.5%	3.0%	2.2%	1.8%	1.6%	1.3%	1.5%

Fig. 8. Percentages of girls and boys eligible to complete VCE in single-sex and co-educational schools enrolled in IT applications, 2001-2015.

The data in Figure 8 reveal that:

- Higher percentages of boys than girls in both school types study IT applications
- The proportion of girls in both single-sex and co-educational schools studying IT applications has been very similar over time.
- Over time, higher proportions of boys in co-educational than in single-sex schools have enrolled in IT applications
- Over time, there have been very large and steady decreases in the enrolments in IT applications for all students in both school types.

Software development



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Boys - single sex	11.9%	12.6%	9.0%	9.6%	7.5%	6.7%	6.6%	5.4%	4.6%	4.4%	4.3%	4.4%	4.8%	4.4%	4.8%
Girls - single sex	1.9%	2.1%	1.4%	1.0%	0.5%	0.7%	0.5%	0.3%	0.0%	0.4%	0.1%	0.1%	0.0%	0.0%	0.1%
Boys - co-ed	12.3%	11.6%	10.6%	10.2%	7.9%	7.5%	6.3%	5.8%	5.4%	4.8%	5.0%	4.3%	4.8%	5.1%	5.1%
Girls - co-ed	1.4%	1.2%	0.9%	0.7%	0.7%	0.6%	0.3%	0.4%	0.3%	0.3%	0.4%	0.2%	0.3%	0.3%	0.3%

Fig. 9. Percentages of girls and boys eligible to complete VCE in single-sex and co-educational schools enrolled in software development, 2001-2015.

The data in Figure 9 reveal that:

- Substantially higher proportions of boys than girls in both school types have enrolled software development
- In both school types, the proportions of girls in both school types enrolled in software development are strikingly similar; the same pattern is observed for boys.
- Over time, there have been very large and steady decreases in the software development enrolments of boys from both school types; from a very low starting point, the same pattern is evident for girls.

Summary of findings from VCE STEM enrolments 2015

- 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 physics, specialist mathematics, IT applications, and software development.
    - While, for physics and specialist mathematics, there is a higher proportion of girls from single-sex than co-educational schools enrolled, the same is true among boys in the two school types.
- Higher proportions of girls and boys in single-sex schools than in co-educational schools are enrolled in biology, chemistry, and 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.

While it would appear that girls in single-sex schools are enrolled in many of the STEM VCE subjects in higher proportions than girls from co-educational schools, the same pattern is generally evident for boys. It would appear to be too simplistic to conclude that it is the gendered setting of the school alone that contributes to this.

Socioeconomic-status plays an important role in academic outcomes, as well as in decisions about subject choice. According to the Australian Bureau of Statistics (2006), fee-paying non-government schools are, on average, at higher SES levels than government schools. There is much research evidence that school and family backgrounds are major contributing factors to student achievement (e.g., Hattie, 2009). Cobbold (2015) maintained that in Australia, and many other countries, "school SES has a much larger impact on student achievement than individual family SES" (pp. 4-5). According to Australian Catholic University (2011), the average *Index of Community Socio-Educational Advantage* [ICSEA] score for government schools in Australia was 988.16, lower than for non-government schools which was 1027.93. In combination, prior achievement, expectations of those in the social milieu, school factors including teachers, and confidence levels all contribute to subject choice decisions (e.g., Eccles, 1994, Hattie, 2009).

To tease out the complex interplay of factors impacting on the differences in STEM subject enrolments for girls attending single-sex and co-educational schools, as well as the larger differences between boys' and girls' STEM enrolments, we conducted an online survey of graduates of single-sex and co-educational schools. The survey results (discussed in detail later in this report) revealed that a higher proportion of females from single-sex than co-educational schools had completed studies in STEM-related health fields, while a higher proportion of females from co-educational schools than single-sex schools had completed engineering studies. This may be related to the finding that parents of females who had attended single-sex schools appeared more influential in their daughters' career choices than parents of females who had attended co-educational schools.

From the survey data, it was also found that the traditional gender stereotyped role expectation that females serve as the main carer for children was evident not only among older participants, but also, disappointingly, among younger participants. This gendered expectation, as well as harassment and bullying in male-dominated fields (e.g., engineering), were provided by many survey respondents as explanations for career changes away from STEM.

A noteworthy finding was that the female respondents were far more likely to say that they would recommend a single-sex school to promote a girl's interest in STEM than for a boy. This finding is consistent with the widespread belief that single-sex schools are more likely than co-educational schools to promote girls' interests in STEM.

Methods

The instrument

An online survey questionnaire was developed. Closed (scorable) items were included with participants often asked to explain the responses given. Other items were open-ended, allowing participants to provide extended responses to the questions.

Biographical (e.g., gender, age, decade of school completion etc.) and demographic data (school type attended, location of school etc.) were sought in the first section. Items were also included to explore which STEM (or other) subjects were completed in the final year of schooling and reasons for doing so, STEM career trajectories and factors supporting or inhibiting participation in STEM occupations.

It should be noted that the school-level STEM subjects included: physics, chemistry, biology, IT, and three levels of mathematics subjects – subjects common to state-level offerings in Australia over time. The STEM occupations were those identified by the Chief Scientist of Australia (Finkel, 2016).

Participants were also asked to recommend which school type (co-education or single-sex) they would recommend for boys and for girls interested in STEM; they were invited to explain their recommendations.

A copy of the online survey instrument is found in Appendix B.

The sample

As only one online survey was used in the study, we were unable to distinguish between responses received by way of Facebook advertising and those resulting from the requests sent to alumnae of Alliance schools. As noted earlier, not all respondents provided answers to each question. Thus, there are small variations in total sample sizes for each question discussed in the report.

Data cleaning

When the survey was closed, the full set of responses was downloaded. Data cleaning procedures were then undertaken. Not all surveys were fully completed. However, it was pleasing to find that around 80% of those who started the survey answered the bulk of the items.

It was decided to eliminate all survey responses from New Zealanders and non-binary respondents (see caveats above), as well as all surveys in which respondents had only provided biographical/demographic data, that is, no items central to the study had been answered.

The full Australian sample comprised 1218 respondents, of whom 83 (6.8%) were male and 1135 (93.2%) were female. Eight of these respondents were excluded from analyses by school type as they selected “other” as the school type (5 females, 1 male) or did not respond to the item (2 females) about the school type attended in the final year of schooling.

Sample used in analyses

The final female sample of 1128 involved in subsequent analyses by school type attended (single-sex or co-educational) comprised 964 (85.5%) who had completed their final year of schooling at single-sex schools (the SS sample) and 164 (14.5%) at co-educational schools (the Co-ed sample). Of the 82 males, 24 had completed schooling in single-sex schools (too few for any robust analyses) and 58 in co-educational schools (sufficient for comparisons with females from co-educational schools).

Results

Background information (all respondents) by age, type of school attended, decade school completed (relates to Aims 1 & 4)

Selected background information for the full sample, and by gender, is summarised in Table 1[3].

Table 1.

Background information: Full sample by gender

	Males		Females		All	
	N	%	N	%	N	%
Age						
18-20	13	15.7	94	8.3	107	8.8
21-30	18	21.7	264	23.3	282	23.2
31-40	9	10.8	233	20.5	242	19.9
41-50	12	14.5	226	19.9	238	19.5
51-60	12	14.5	170	15.0	182	14.9
61-70	16	19.3	99	8.7	115	9.4
Over 70	3	3.6	49	4.3	52	4.3
School attended						
Government	40	48.2	124	10.9	164	13.5
Catholic	12	14.5	90	7.9	102	8.4
Independent	30	36.1	893	78.7	923	75.8
Other	1	1.2	28	2.5	29	2.4
Metropolitan	64	77.1	1060	93.4	1124	92.3
Non-metropolitan	18	21.7	62	5.5	80	6.6
Co-educational	58	69.9	165	14.5	223	18.3
Single-sex boys	24	28.9			24	2.0
Single-sex girls			964	84.9	965	79.2
Other	1	1.2	5	.4	6	.4
Decade school completed						
1940-1949[4]			1	.1	1	.1
1950-1959	1	1.2	26	2.3	27	2.2
1960-1969	8	9.6	60	5.3	68	5.6
1970-1979	10	12.0	138	12.2	148	12.2
1980-1989	14	16.9	188	16.6	202	16.6
1990-1999	6	7.2	216	19.0	222	18.2
2000-2009	12	14.5	228	20.1	240	19.7
2010-2016	20	24.1	194	17.1	214	17.6

[3] It should be noted that not all respondents provided all background information requested on the survey.

[4] As there was only one respondent who completed schooling in the 1940s, she has been excluded from many subsequent analyses by decade of school completion.

The data in Table 1 reveal the following:

- There was a wide age range of respondents – both male and female. This was consistent with the range of variation in the decade in which school was completed;
- Among female respondents, a much higher percentage completed their final year of schooling at independent schools (78.7%) than the proportion of female students currently enrolled in independent schools in Australia; ABS data indicate that 14.4% of all Australian students attended independent schools in 2015 (see http://www.abs.gov.au/ausstats/abs@.nsf/mf/4221.0).

  A similar, although less extreme, pattern was also noted for males.

  The extent of the skewing of the female sample is best explained by the likely successful sampling of alumnae from single-sex girls' schools, predominantly found in the independent sector.
- The vast majority of respondents had attended schools in the metropolitan capitals.

Subjects studied at year 12 (all respondents)

The STEM subjects studied at year 12 for the full sample, and by gender, are shown in Table 2

Table 2.

The STEM subjects studied in the final year of schooling, by gender, for the full sample

	Males		Females		Total	
	N	%	N	%	N	%
Physics	43	51.8	370	32.6	413	33.9
Chemistry	48	57.8	529	46.6	577	47.4
Biology	16	19.3	514	45.3	530	43.5
Advanced level Mathematics	39	47.0	378	33.3	417	34.2
Intermediate level Mathematics	42	50.6	475	41.9	517	42.4
Elementary level Mathematics	9	10.8	126	11.1	135	11.1
IT/Computing	10	12.0	63	5.6	73	6.0
None of the above (i.e., non-STEM)	4	4.8	89	7.8	93	7.6

Figures 10 and 11 contain, respectively, the STEM subjects studied by the full sample in the final year of schooling and the VCE enrolments in comparable STEM subjects in 2015, by gender.

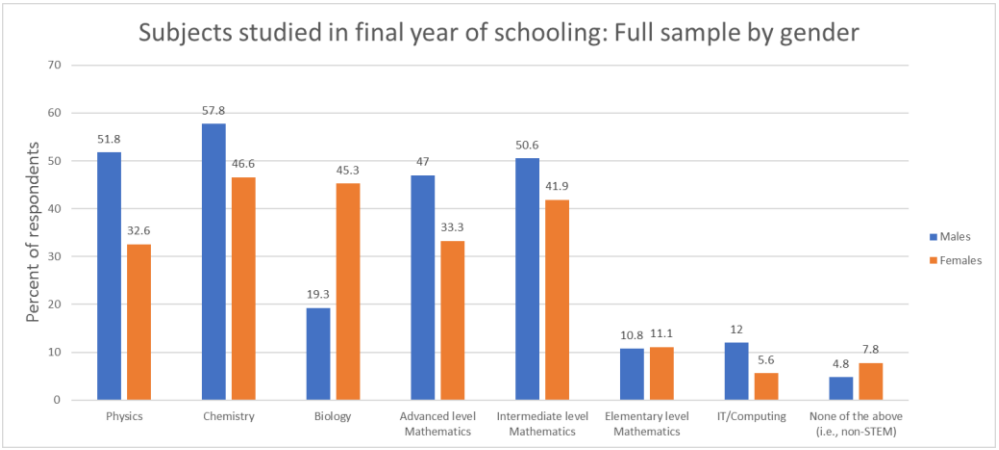


Figure 10. Subjects studied in the final year schooling for the full sample by gender

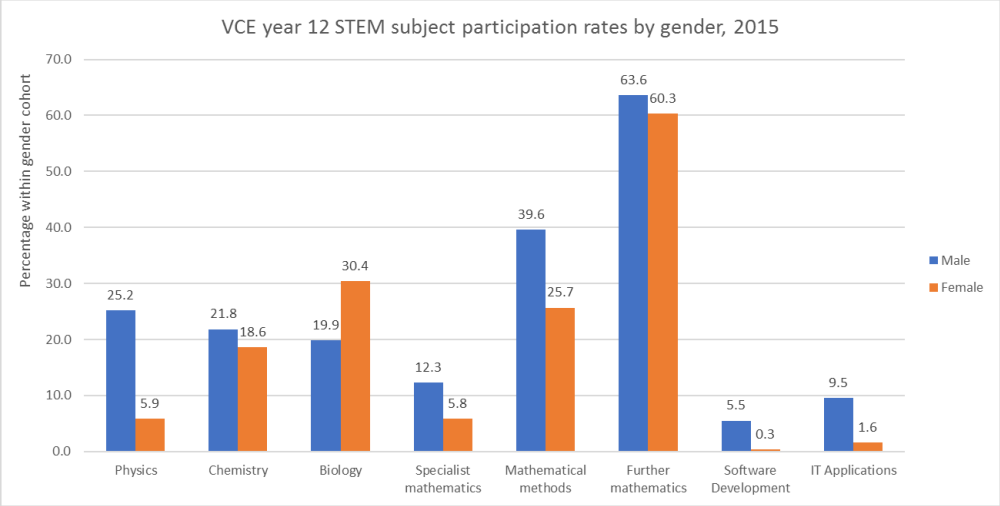


Figure 11: VCE enrolments in STEM subjects in 2015 by gender

The data illustrated in Figures 10 and 11 reveal that the percentages of males and females enrolled in the various STEM subjects are different for the full sample and for VCE in 2015. Nonetheless, some similarities in the graphs are evident. It can be seen that:

- The percentages of females in the study who studied each of the STEM subjects was higher than the percentages of the female 2015 VCE cohort who did so.
- The direction of the gender differences in enrolments for the study sample are very similar to those in the 2015 VCE cohort.
- In the study sample, higher proportions of males than females reported studying physics, chemistry, advanced level mathematics, intermediate level mathematics, elementary level mathematics and IT in their final year of schooling. Similarly, in VCE in 2015, higher proportions of males than females studied physics, chemistry, specialist mathematics, mathematical methods, further mathematics, and the two IT subjects.
- Among the study sample and in the 2015 VCE, the gender difference was in the opposite direction for biology in that there were higher proportions of females than males who studied biology.

The data in Figures 10 and 11 together indicate that the recruitment strategies adopted for the study resulted in a respondent sample skewed towards STEM interest and/or STEM career involvement. Although the male study sample was small, it was particularly noteworthy that the same pattern of gender differences was evident in the enrolments reported by those participating in this study as was found for the 2015 VCE cohort.

Background information for all females in the sample (by attendance at SS or Co-ed school) (relates to Aims 1 & 2)

Background Information for the full female sample (by school type attended) is recorded in Table 3: age, decade school completed, progression to higher education, qualifications completed (more than one could be specified). It can be seen in Table 3 that:

1. There were no major differences in the age profile of the two groups (SS or Co-ed)
2. There was little difference between the profiles of the two groups with respect to the decade of school completion

3. With respect to higher education and post-school qualifications, there was again no appreciable difference between the two groups.

Table 3.

Background information for the female sample by school-type attended

	Co-ed		Single-Sex		Total	
	N	%	N	%	N	%
Age						
18-20	14	8.5	79	8.2	93	8.2
21-30	28	17.1	236	24.5	264	23.4
31-40	39	23.8	192	19.9	231	20.5
41-50	39	23.8	186	19.3	225	19.9
51-60	20	12.2	148	15.4	168	14.9
61-70	19	11.6	79	8.2	98	8.7
Over 70	5	3.0	44	4.6	49	4.3
Total	164	100.0	964	100.0	1128	100.0
Decade school completed						
1940-1949	0	0.0	1	0.1	1	0.1
1950-1959	3	2.0	23	2.6	26	2.5
1960-1969	10	6.7	49	5.5	59	5.6
1970-1979	20	13.4	117	13.0	137	13.1
1980-1989	27	18.1	160	17.8	187	17.9
1900-1999	32	21.5	183	20.4	215	20.6
2000-2009	34	22.8	193	21.5	227	21.7
2010-2016	23	15.4	171	19.1	194	18.5
Total	149	100.0	897	100.0	1046	100.0
Post school studies						
Yes	149	92.0	874	91.3	1023	91.4
Post-school qualifications[5]						
Certificate	36	22.0	204	21.2	240	21.3
Diploma	26	15.9	152	15.8	178	15.9
Advanced Diploma	6	3.7	60	6.2	66	5.9
Bachelors Degree	126	76.8	720	74.7	846	75.0
Graduate Diploma	34	20.7	172	17.8	206	18.3
Graduate Certificate	9	5.5	70	7.3	79	7.0
Masters degree	29	17.7	166	17.2	195	17.3
Doctoral degree	12	7.3	62	6.4	74	6.6

In summary, the samples of female participants who completed their final year of schooling in single-sex and co-educational schools are very similar. Both groups were well qualified with about 75% of each group having completed at least a bachelors degree, 17% a Masters degree, and around 7% a doctoral degree. National data for 2011 indicate that 41.7% of women had a bachelors degree and 10.5% had postgraduate (Masters/PhD) (ABS, 2012). Clearly, given that our female sample's

[5] Using an open-ended comment box, we attempted to obtain clarification on the disciplinary areas in which people reported having certificates, diplomas, bachelor degrees etc. Unfortunately, responses were so varied, this proved to be an unmanageable task to handle.

educational qualifications were achieved over a wide time period, they were highly qualified compared to the general Australian female population.

STEM subjects studied in final year of schooling: All females (relates to Aim 1)

For all females, the STEM subjects studied in their final year at school, by respondents' age group and by decade of school completion, are shown in Table 4.

Table 4.

STEM subjects studied in final year of schooling: All females, by age and decade of school completion

	Advanced maths		Intermediate maths		Elementary maths		Physics		IT/ Computing		Chemistry		Biology	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
						Age								
18-20	30	32.3	44	47.3	10	10.8	24	25.8	8	8.6	46	49.5	34	36.6
21-30	87	33	131	49.6	35	13.3	73	27.7	15	5.7	140	53	97	36.7
31-40	91	39.4	117	50.6	23	10	97	42	19	8.2	126	54.5	110	47.6
41-50	81	36	93	41.3	27	12	78	34.7	19	8.4	104	46.2	107	47.6
51-60	49	29.2	50	29.8	21	12.5	58	34.5	2	1.2	67	39.9	106	63.1
61-70	25	25.5	27	27.6	5	5.1	27	27.6	0		31	31.6	36	36.7
Over 70	14	28.6	10	20.4	5	10.2	13	26.5	0		13	26.5	22	44.9
						Decade school completed								
1940-1949	0	0	1	100	0	0	1	100	0	0	1	100	0	0
1950-1959	7	26.9	7	26.9	1	3.8	6	23.1	0	0	5	19.2	12	46.2
1960-1969	19	32.2	8	13.6	8	13.6	19	32.2	0	0	22	37.3	21	35.6
1970-1979	35	25.5	45	32.8	15	10.9	47	34.3	1	0.7	56	40.9	85	62
1980-1989	65	34.8	67	35.8	19	10.2	70	37.4	7	3.7	84	44.9	99	52.9
1990-1999	89	41.4	106	49.3	23	10.7	92	42.8	27	12.6	112	52.1	96	44.2
2000-2009	71	31.3	112	49.3	33	14.5	65	28.6	14	6.2	116	51.1	91	40.1
2010-2016	69	33.9	97	50	18	9.3	52	26.8	10	5.2	103	53.1	73	37.6

The STEM subject data by decade of school completion are also illustrated in Figure 12 (Advanced mathematics, Intermediate mathematics, and Elementary mathematics) and Figure 13 (Physics, Chemistry, IT/Computing, and Biology).

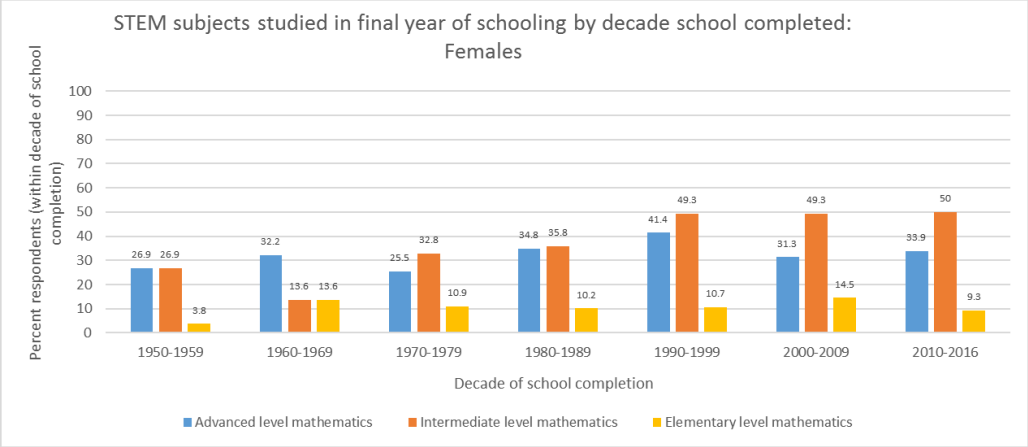


Figure 12. Percentages of all females studying Advanced mathematics, Intermediate mathematics, and Elementary mathematics in their final year of school by decade of school completion.

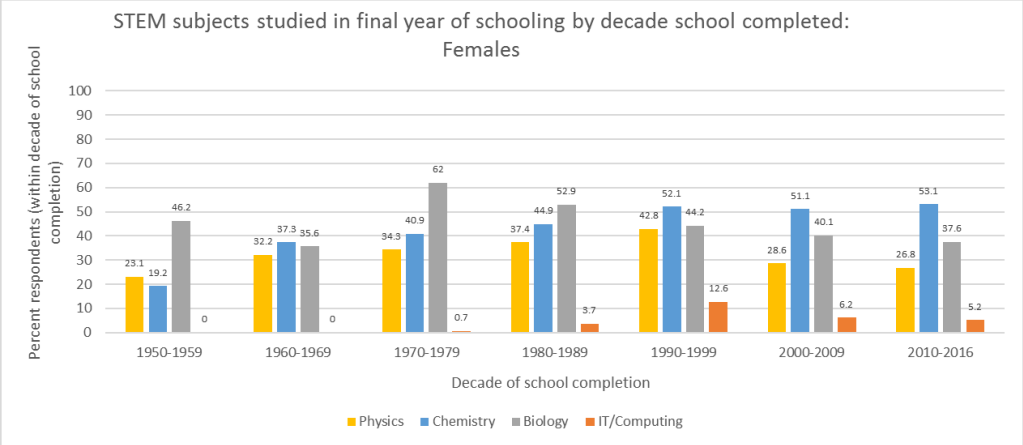


Figure 13. Percentages of all females studying Physics, Chemistry, IT/Computing, and Biology in their final year of school by decade of school completion.

Interesting trends over time are also revealed in Figures 12 & 13.

a. Biology: decreased after 1970-1979
b. Physics, Advanced mathematics, and IT/Computing: trended up until 1990-1999 then declined after that time
c. Chemistry and Intermediate mathematics: trended up until 1990-1999, then remained fairly steady.

In summary, the decade of 1990-1999 appears to have been the period in which the participants' enrolments in STEM-related subjects were at a peak. The decade was one in which gender equity in educational outcomes was a priority. At the same time, following a national move in the late 1980s for Australia to have a common national curriculum rather than separate state curricula, major changes in the subject offerings and assessment regimes in the final years of schooling were in evidence. In Victoria, for example, the examination-based one-year Victorian Higher School Certificate was replaced with the two-year Victorian Certificate of Education, in which school-based assessments as well as traditional timed examinations contributed to final results. In 1990, the federal government developed the policy, *A fair chance for all: Higher education that's within everyone's reach*. Aims included an "increase in the proportion of women in non-traditional courses, other than engineering, from the current level to at least 40% by 1995 [and] an increase in the proportion of women in engineering courses from 7% to 15% by 1995" (Australian Bureau of Statistics [ABS], 2004). Between 1988 and 1992, it was reported that "the proportions of women enrolled in non-traditional courses increased" (ABS, 2004) and that "although there has been some movement of women into non-traditional courses, male students have continued to make conventional choices" (ABS, 2004). The impact of these efforts may partially account for the increased enrolments in STEM-based subjects during the decade.

STEM subjects studied in final year of schooling: All females by school type attended (relates to Aims 1 & 2)

The STEM subjects studied by females in their final year of schooling are shown in Table 5 separately for those from co-ed and SS schools, as well as for the total sample of females.

Table 5.

Subjects completed in the final year of schooling: All females by school type attended (single-sex or co-educational)

	Co-ed		Single-Sex		Total	
Subject	N	%	N	%	N	%
Advanced maths	71	43.3	306	31.7	377	33.4
Intermediate mathematics	66	40.2	406	42.1	472	41.8
Elementary mathematics	21	12.8	105	10.9	126	11.2
Physics	69	36.6	310	32.2	370	32.8
IT/Computing	11	6.7	52	5.4	63	5.6
Chemistry	77	47.0	450	46.7	527	46.7
Biology	65	39.6	447	46.4	512	45.4
None of these	12	7.3	77	8.0	89	7.9

The data in Table 5 reveal some minor differences between the single-sex and co-educational groups of female participants in the STEM subjects studied in the final year of schooling:

- A higher proportion of the co-educational group than the single-sex group had studied advanced level mathematics.
- Slightly higher proportions of the co-educational group than the single-sex group had studied physics, IT/Computing, and elementary level mathematics
- A higher proportion of the single-sex group than the co-educational group had studied biology in their final year of schooling
- A slightly higher proportion of the single-sex group had studied intermediate level mathematics

In summary, there were slight differences in the profiles of the two groups with respect to the STEM subjects studied in the final year of schooling. It cannot be simplistically assumed school-type alone fully explains the differences found. For example, different pre-requisites were needed for tertiary qualifications, particularly in earlier times. Thus the occupations fields represented by the samples of females may have been a contributing factor.

It is worth noting that the VCE data for enrolments in the Victorian subjects equivalent to those listed in Table 5 by school type (see earlier in the report) differed somewhat from those for the sample in this study. For example, in Specialist maths (VCE subject) in 2015, there were 8.9% of females from single-sex schools and 4.8% of girls from co-education schools enrolled in the subject. This difference in favour of females from single-sex schools contrasts with the higher proportion of co-educational female respondents (43.3%) compared to 31.7% from single-sex schools indicating that they had studied Advanced maths (Table 5). There may be multiple reasons for the variations between the VCE and study samples. These include:

- While VCE data may be broadly representative of Australia as a whole, it can be seen in Figure 1 that Victoria has the highest proportion of single-sex girls' schools in the country
- The sample was biased in favour of respondents focussing on STEM subjects and careers.
- Among the single-sex sample in the study, there were some alumnae of single-sex schools who indicated an interest in the STEM area and had studied STEM-related subjects in their final school of schooling, but not necessarily with the intention of building on them into STEM-focussed careers. Here's what one alumna added at the end of the survey

Not sure if I was meant to do this survey? I was asked as an alumna of my school but don't have any experience in STEM-related careers. I was specifically put off them at school because of advice that there was a lack of jobs, especially for women.
(21-30 year-old, studied Advanced maths, biology, economics, business management, and Advanced English in her final year of schooling. Described her career as "business, finance, management".

Occupations fields: all females by school-type attended (relates to Aims 1 & 2)

From a list of STEM occupations (as defined by the Chief Scientist of Australia), participants were asked to identify which broad field best fitted with their current occupations. The results are shown in Table 6.

Table 6.

Current occupational field: All females by school-type attended (single-sex or co-ed)

	Co-ed		Single-Sex		Total	
Occupational field	N	%	N	%	N	%
Physical or biological sciences	2	1.6	17	2.4	19	2.3
Agricultural, environmental, or related (science) studies	3	2.4	27	3.8	30	3.6
Information Communication Technology/Computing	5	4.0	30	4.2	35	4.1
Engineering	18	14.3	28	3.9	46	5.5
Mathematics	3	2.4	5	0.7	8	0.9
Health or allied health sciences	24	19.0	203	28.3	227	26.9
Science/IT/Mathematics teaching at secondary or post-secondary level	7	5.6	18	2.5	25	3.0
Other - please explain*	64	50.8	390	54.3	454	54.0

* About half of all participants selected "other", choosing to describe their occupations in their own words. The diversity and complexity of the responses provided again proved to be an unmanageable task to handle.

As can be seen in Table 6, there were differences in the response patterns for the two groups. A chi-square test revealed that the distribution of the specified occupational fields differed by school background (χ^2 = 35.0, df = 14, p=.001). In particular, a higher percentage of females who attended single-sex schools than co-educational schools reported working in the health or allied health sciences (28.3% compared to 19.0%). On the other hand, a higher proportion of females from co-educational schools than single-sex schools reported working in Engineering (14.3% compared to 3.9%) and Mathematics (2.4% compared to 0.7%). These differences may partially explain the higher proportions of females in our sample from co-educational schools than single-sex schools having studied Advanced mathematics and Physics (see Table 5) in the final year of schooling. These subjects were pre-requisites (or highly recommended) for entry into Engineering courses, particularly in earlier times. The much higher proportion of females from single-sex than co-educational schools in the health and allied health sciences (28.3% compared to 19.0%) may be related to the numbers studying biology and intermediate level mathematics in their final year of schooling; these subjects are closely aligned to the recommended backgrounds for tertiary studies in the health field.

Factors influencing choice of initial career (NB. both SS and Co-ed data)

Our survey respondents were asked to indicate which one or more, from a provided list of factors, were influential in their initial career pathways. They were also asked to identify which one of these was the most influential. Female participants' responses by school type attended are shown in Table 7.

Table 7.

Factors influencing the choice of initial career: All females by school type attended

Reason	Co-ed		Single-Sex		Total	
	N	%	N	%	N	%
Good at ≥1 STEM subjects	73	44.5	362	37.6	435	3
Teachers	45	27.4	281	29.1	326	28.9
Career advice	38	23.2	225	23.3	263	23.3
Parents	64	39.0	418	43.4	482	42.7
Other family	17	10.4	119	12.3	136	12.1
Friends	25	15.2	130	13.5	155	13.7
Good employment prospects	57	34.8	307	31.8	364	32.3
Wanted STEM occupation	29	17.7	176	18.3	205	18.2
Employer help	8	4.9	40	4.1	48	4.3
Other	45	27.4	224	23.2	269	23.8

From Table 7 it can be seen that the three most frequently mentioned factors were parents, good at one or more STEM subjects, and good employment prospects, irrespective of school type attended. Parents were mentioned more frequently by those from single-sex schools (43.4%) than by those from co-educational schools (39.0%). Being good at one or more STEM subjects was the most frequently identified factor by those from co-educational schools (44.5% compared with 37.6% by single-sex participants).

When asked to select the most influential factor, females who attended single-sex schools chose being good at one of more STEM subjects most often (19.1%), followed by parents (18.5%), and good employment prospects (13.0%). Those who had attended co-educational schools similarly selected being good at one of more STEM subjects most often (20.4%), followed by parents (13.4%), and good employment prospects (13.4%). Interestingly, the ordering of the three most influential factors was the same. However, parents seemed to have somewhat greater influence on those who had attended single-sex schools.

While mentioned by many respondents, school-based influences such as teachers and career advice did not feature in the top three factors identified as influential, nor in the most influential factors.

Single-sex only – more details

The increase in the participation in Physics, Advanced mathematics, and Intermediate mathematics until the decade 1990-1999 was highlighted earlier. When we examined the data more closely for the large sample of respondents from single-sex schools who completed schooling in the decades 1980-1989, 1990-1999, and 2000-2009, we noted some minor, but interesting, variations. For those from the 1980s and the 2000s, parents were selected as the most influential factor (17.1% and 19.3% respectively) for choice of the initial career path, while in the 1990s, 'being good at the subject' was identified as the most influential factor (24.9%). A possible explanation for this variation

is likely to be the same as that discussed in relation to the bump in enrolments in the STEM-related subjects in the 1990s (see discussion of social context on p. 15 of this report).

More information about the female respondents who attended SS schools (relates to Aims 1, 2, & 3)

As can be seen from Table 1, 964 female respondents had attended a single-sex school. The data below refer specifically to this group.

STEM subjects studied at year 12 (SS only)

The percentages of female participants attending single-sex schools who studied the various STEM-related subjects in their final year of school are found in Tables 8 & 9.

Table 8.

Mathematics subjects and Biology studied in the final year of schooling by respondents' age and decade of school completion (SS school females only)

	Advanced maths		Intermediate maths		Elementary maths		Biology	
	N	%	N	%	N	%	N	%
Age								
18-20	23	29.1	36	45.6	9	11.4	25	31.6
21-30	74	31.4	114	48.3	30	12.7	88	37.3
31-40	71	37.1	103	53.6	20	10.4	91	47.4
41-50	60	32.3	82	44.1	20	10.8	92	49.5
51-60	45	30.5	44	29.7	17	11.5	98	66.2
61-70	21	26.6	20	25.3	5	6.3	31	39.2
Over 70	12	27.3	7	15.9	4	9.1	22	50.0
Decade school completed								
1940-1949	0	0	1	100	0	-	0	-
1950-1959	6	26.1	4	17.4	1	4.3	12	52.2
1960-1969	15	30.6	5	10.2	7	14.3	20	40.8
1970-1979	32	27.4	39	33.3	14	12.0	77	65.8
1980-1989	52	32.5	57	35.6	14	8.8	88	55.0
1990-1999	70	38.3	96	52.5	19	10.4	84	45.9
2000-2009	56	29.0	98	50.8	27	14.0	73	37.8
2010-2016	58	33.9	82	48.0	16	9.4	63	36.8

As for the full sample of females (see Table 4, Figures 12 & 13), it can be seen in Tables 8 & 9 that the decade 1990-1999 saw peaked enrolments in Advanced mathematics and physics. Possible explanations for this were discussed earlier.

Table 9.

Physics, IT/Computing, Chemistry, and no listed STEM subjects studied in the final year of schooling, by respondents' age and decade of school completion (SS school females only)

	Physics		IT/Computing		Chemistry		None of the listed STEM subjects	
	N	%	N	%	N	%	N	%
Age								
18-20	18	22.8	7	8.9	40	50.6	12	15.2
21-30	61	25.8	15	6.4	124	52.5	18	7.6
31-40	80	41.7	16	8.3	102	53.1	8	4.2
41-50	64	34.4	12	6.5	87	46.8	6	*3.2*
51-60	54	36.5	2	1.4	60	40.5	7	4.7
61-70	21	26.6	0	0	25	31.6	16	20.3
Over 70	12	27.3	0	0	12	27.3	10	22.7
Decade school completed								
1940-1949	1	100	0	-	1	100	0	0
1950-1959	6	26.1	0	-	5	21.7	7	30.7
1960-1969	15	30.6	0	-	18	36.7	10	20.4
1970-1979	43	36.8	1	0.9	49	41.9	6	5.1
1980-1989	60	37.5	3	1.9	72	45.2	7	4.4
1990-1999	78	42.6	22	12.0	96	52.5	4	2.2
2000-2009	56	29.0	13	6.7	96	49.7	13	6.7
2010-2016	40	23.4	9	5.3	93	54.4	20	11.7

Educational and occupational data (SS females only)

Shown in Table 3, 91.3% of all female respondents attending single-sex schools had continued on to post-school studies. These data are shown by respondent and decade of school completion in Table 10. Also included in Table 10 are the percentages of respondents in paid employment.

Table 10.

Single-sex school females who completed post-school studies after the final year of schooling, and are in current employment by age and decade of school completion

	Post-school education		In paid employment	
	N	%	N	%
Age				
18-20	47	60.3	45	59.2
21-30	215	92.3	199	86.1
31-40	188	97.9	178	93.2
41-50	177	95.7	164	90.1
51-60	140	94.6	115	79.3
61-70	71	91.0	38	48.1
Over 70	36	83.7	5	11.6
Total	874	91.3	744	78.6
Decade school completed				
1940-1949	1	100	0	-
1950-1959	19	82.6	2	8.7
1960-1969	46	95.8	17	35.4

	Post-school education		In paid employment	
	N	%	N	%
1970-1979	110	94.0	88	76.5
1980-1989	154	96.9	141	89.2
1990-1999	177	96.7	163	90.6
2000-2009	182	94.8	176	92.1
2010-2016	130	77.4	116	70.3
Total	819	91.9	703	79.8

As expected, the data in Table 10 reveal that lower percentages of participants aged 18-20 and those over 60 years of age were currently employed.

Factors influencing initial career paths, by age (SS females only)

Earlier we discussed the influences on initial career paths for females who had attended single-sex schools – see Table 7 and related text.

Factors supporting or hindering career paths and goals (SS females only; qualitative data) (related to Aim 3)

Participants were asked to describe who or what had supported and/or hindered their career paths and goals. [This item was different from the question about initial career influences.] The open-ended responses were coded by theme for a random sample of 164 of the 964 female respondents from single-sex schools. The results are shown in Figures 14 & 15. [NB. Some respondents mentioned more than one factor, hence percentages do not add to 100%]

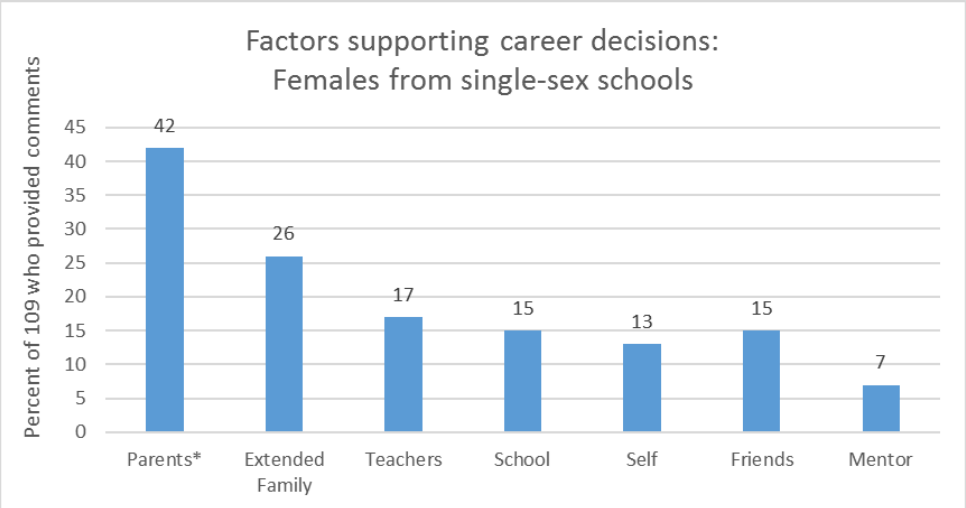


Figure 14. Factors supporting career paths and goals for females from single-sex schools

Supportive factors cited most frequently were parents, extended family, and teachers (see Figure 14). Again, the influence of parents can be seen to be very strong. School-based factors (teachers and the school itself) are mentioned frequently, but not as often as parents and extended family.

Some examples of what participants wrote about who or what supported their career paths and goals include:

> My parents and the opportunities and support they have provided me with. (21-30 year old)

> Supportive teachers at school who instilled in me the idea that anything was possible. (21-30 year old)

Family members and friends, getting into a university course that had the option of part-time so that I could start working sooner, HECS, industry colleagues. (31-40 year old)

Family has been the biggest support - always making me believe that I could pursue what I wanted to and never making me feel pressured into particular paths, even as I pursued multiple options and made changes through my career. Teachers and school were very supportive of pursuing science all the way as a school age student. A chemical engineering dean/professor who encouraged us from the start not to think of chemical engineering as "just a degree that lets you work in a petrochemical plant" but instead as a blueprint of how to deconstruct and solve complex problems in any field. Flexible and supportive workplace in Australia that let me take a year off to pursue a Masters of Law overseas; and then the mind-expanding experience of my overseas study which ultimately led me to relocate and pursue a whole different career that culminated and expanded on my previous study and experiences. Another big factor was staying open minded to changing path rather than getting "stuck" in one kind of job - and to having enough faith in my inherent employability that I could take risks and make changes, without being unduly influenced by a perception of needing "stability", which I think hampers many people in their goals. (31-40 year old)

Father who insisted that girls could and should do what they like. (51-60 year old)

My mother as a single mother raising three children following the death of her husband and having an education that was interrupted by the war and very little money was very committed to getting her two daughters educated in case they met the same fate.
From 24 my husband as an older and reasonably senior and highly committed public servant provided a mentor type role for most of the rest of my career. (61-70 year old)

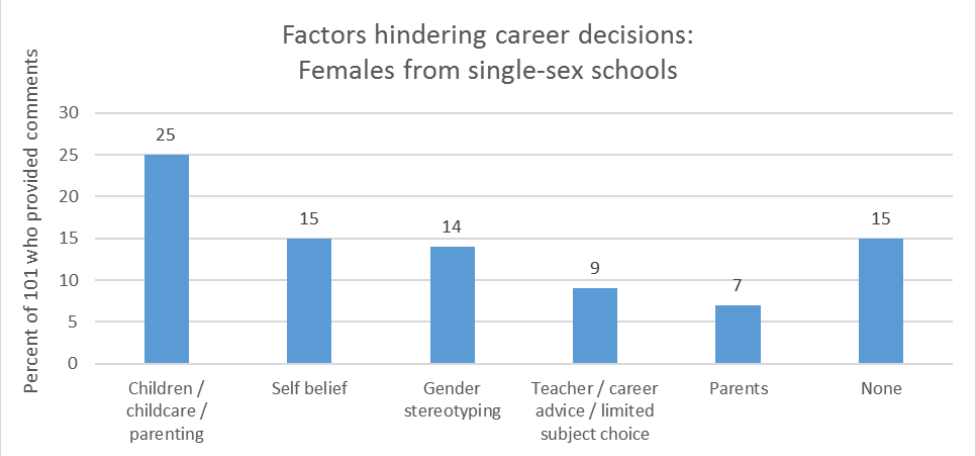


Figure 15. Factors hindering career paths and goals for females from single-sex schools

Obstacles mentioned most frequently were children and parenting responsibilities, self belief, and gender stereotyping (see Figure 15). While mention of these barriers was not surprising from older participants, disappointingly, they were also cited by younger women. That some respondents indicated that they had not experienced any particular hindrances is noteworthy, as were the dual impacts of parents and of self belief (supportive according to some but cited as a hindrance by others).

Representative examples of what participants wrote about who or what hindered their career paths and goals include:

Society stereotypes and some teachers who weren't supportive (18-20 year old)

Career advice was very narrow minded at times, which meant it was hard to come up with back ups if you didn't get into your first choices in what you wanted to do, career counsellor had less information than what was online. (21-30 year old)

At school: expectations that as successful student I should apply for law or medicine, and lack of extracurricular activities for maths and the physical sciences compared to sporting pursuits and the arts. In general: stress due to family circumstances, perfectionism, physical injury. (21-30 year old)

Nothing really - even having children of my own has not been a significant impediment as I have been fortunate to have flexible employers that are willing to let me work part time doing the same kind of work. Given my choice not to work full time while I have a very young family, that is a barrier to taking further steps towards management positions. But this barrier is a self-imposed choice due to my desire to give my children the same kind of supportive and stimulating environment that I had growing up. (31-40 year old)

I came across very few barriers prior to taking maternity leave and then everything changed. (31-40 year old)

Being female had some barriers - I had to prove myself to be accepted. (41-50 year old)

The lack of mentoring at my school, coupled with a number of horribly indifferent (aka bitchy) private girls served as a barrier as it completely shattered my sense of self worth. (41-50 year old)

My choice of medical specialty was influenced by gender bias including little availability of family friendly training options. (51-60 year old)

I created my own barriers through a lack of self-confidence due to this I have not sought promotion or applied for promotion. In fact I applied for promotion on my own volition for the first time a few weeks ago. I have usually waited to be invited to apply. Don't ask me where this lack of self confidence came from but it has been a real barrier. Despite this I have been very lucky and have had a very interesting career including working for working for the XXX (international organisation) on river basins under the YYY Program in the 1990s. Added to this I have probably followed my husband too early. I followed him to Melbourne in the early 80s with one subject to go on my masters at (state-based) University. This was a result of not be able to negotiate our future effectively. (61-70 year old)

Factors influencing change of career (relates to Aims 2 & 4)

Participants (males and females) who had attended Co-ed schools

Participants were asked if they had changed careers and, if so, what the main factors influencing their decisions were. Given that the sample of males from single-sex schools was too small for any analyses, we turned to the samples of males and females who attended co-educational schools to explore possible gender differences in factors influencing career changes.

The sample of participants who had attended co-educational schools comprised 164 females and 58 males. Just under half of the 222 respondents (93 = 42%) indicated that they had changed careers: 75 (46%) of the females[6], and 18 (31%) of the males. The higher proportion of younger males than younger females in the co-educational sample may be one explanation for proportionally fewer males than females having changed careers.

The co-educational females gave multiple reasons for the career changes made. These included natural progression, wanted a change, retirement, redundancy, change of location, but most frequently children/raising a family and personal circumstances by 17 (23%) of the female participants.

Typical examples from 41-50 year old females include:

[6] By way of comparison, 57 of the 164 females (35%) in the random sample from single-sex schools indicated they had changed career.

> It is still a struggle to be a parent and a leader in major corporations, unless like me you have a home dad for your kids. It is a struggle. (F, 41-50)
>
> The decision was work/home balance. Left Management to enter retail sector. Ability to care for children and work whilst one parent was home. Not a choice but a necessity. Office Management hours were not available to fit with raising children. (F, 41-50)
>
> Opportunity. Never stopped looking for work. Probably never will now. Had an on-going job; fell pregnant; required to return to work full-time when childcare was not available for sick children; been job-hopping ever since (16 years ago). Did a PhD under time, under budget when the kids were small because I could not find a job and needed something to do and an income. The MOST critical factor limiting work options was lack of networks and peer identity as a professional with professional interests/skills. I think this compromises your confidence and creates a negative cycle that is very hard to get out of (because there is no help and considerable social pressure to be 'grateful' because you are a female and somehow meant to desire unpaid primary care while also not meant to need financial independence as much as a male (despite living longer). I have a lot of issues with the endless pressure to be grateful for being desperate to work, never able to use your skills, finding no support, while at the same time biologically/socially/financially charged with mentoring your daughters to believe they have equal opportunity! It is not very encouraging!! (F, 41-50)

Another common reason provided by females was personal circumstances, often – but not always - overlapping with children/family responsibilities. This reason was provided by 14 (19%) of the females. Examples include:

> Changed personal circumstances. After maternity leave for my first child I returned to my management consulting job. When I planned to have a second child, it was too much to juggle so I resigned and took a break from paid employment while my second child was a baby. I took this child to ZZZ (a child care centre) which I then found out was for sale and I liked it so much I bought the business. After 11 years, I sold the business, as it became too much physical work and too time intensive to manage the business, run sessions and manage casual staff. (41-50 year old)
>
> Wanted… an occupation with lower personal pressure and responsibility, and that supported a better work-life balance. (31-40 year old)
>
> Change of personal circumstances made necessary to leave science degree just short of graduating. On returning to study, continued pursuit of multiple years required to specialise in an area of science was not possible. Completed education degree and began working. (41-50 year old)
>
> Didn't enjoy my first career path (or the second...). Wanted to work in the Mining Industry. Changed personal circumstances meant coming back to Australia to study became attractive, so went back to university in AAA (state) to study engineering. (21-30 year old)

The male participants typically volunteered natural progression/ better opportunities, or not liking their previous job as the reason for their career change. None mentioned children or family responsibilities as the reason.

Career change among female participants who had attended SS schools (relates to Aims 2 & 3)

We briefly examined the responses of the whole sample of female participants who had attended single-sex schools: 846 reached this question in the survey. Answers were provided by 315 of the 846, that is 37% of the group[7]. We assumed that if the question was left blank that there had not been a career change.

[7] Note that 35% in the random sample from single-sex schools indicated they had changed career.

As noted above, factors associated with age may be related to career change. We analysed the data by age group and the results are shown in Table 11.

Table 11

Percentages of female participants who attended single-sex schools who changed careers, by age

		Those who changed careers	
Age	**Sample size**	**N**	**%**
21-30	237	56	24
31-40	193	65	34
41-50	187	84	45
51-60	148	80	54
61-70	81	30	37
Total	846	315	37

It can be seen in Table 11, that a larger percentage of the 51-60 year olds (54%) than of any other age group had changed jobs. With the exception of the 61-70 year olds, the percentages changing jobs increased with age (as would be expected).

It was of interest to see what reasons were given for job changes among the 51-60 year old age group (most of whom would have completed school in the 1970s). Personal circumstances, parenting, the impact of gender stereotyping, and issues associated with career opportunities were among the most commonly expressed reasons. Examples from the 51-60 year olds include:

> Bullying - this behaviour is endemic in the medical profession making an already stressful environment a miserable workplace.

> The first career change was due to frustration and disappointment. After completing Honours in Geology (in Sedimentology), I went for job interviews. Instead of being asked about my Honours research I was asked how long I planned to work, if I had a boyfriend and planned to marry! The other Honours students (male, there were 2 female honours students) were asked about their research. This was infuriating! I landed a short-term job with BBB (A state-based electricity commission). I was first woman to work in CCC (coal mining) there. But, I had to fight to go into the mines; the union did not want me there – wanted me to wear different gear, tried to stop me as there were no female toilets, etc. etc. I did go, however, to do stability survey of open cut with another young geologist (male). I then worked in fieldwork for DDD (company) Australia (gold surveys) – again with men who, incidentally, had to sign non- harassment agreements! I had had enough.

> Changed from hands on laboratory work to a more administrative role overseeing government policy for science and funding for innovation. Research and development – more career opportunities.

> At University during my initial degree, I realised that I did not want to work in a scientific role, so I did postgraduate study to allow me to move into administration.

> Did not change career as such, but moved from clinical practice to education in pharmacy as interest in teaching and opportunity arose.

> Personal circumstances; became a mother and couldn't travel or work full-time

> Began Dental Therapy. Completed. Worked full time, part time and then stopped to raise large family.

The reasons provided by younger respondents (most of whom would have completed schooling from the 1980s to more recent times) were similar. However, gender stereotyping was less commonly cited as a reason, but better remuneration, dissatisfaction with (STEM-related) career,

and wanting a change (or being burnt out, or to follow interests) were more often mentioned. Examples include:

> Started dentistry, completed 3 years but didn't enjoy it. Chose to switch to teaching, something that was discouraged when I was in high school as I was 'too smart for that' and 'could do better'. (21-30 year old)

> Two young children at home to prioritise. Being self-employed as a childbirth educator is more flexible than being employed as a psychologist. (21-30 year old)

> B.Sc without PhD had low employability and offered less career pathways/opportunities, forcing me to take up master's degree in a more employable occupation such as nursing. My interest also shifted from academic science to healthcare delivery. (21-30 year old)

> I entered my degree with the intention of becoming an academic and practising clinician in psychology. I am three months out from completing my PhD at present. When I finish, I will be pursuing a career as a psychologist, not an academic. I love clinical work AND research and teaching. The factors behind my decision not to pursue academia, are the lack of funding in academia and the resulting work environment i.e. excessively long working weeks, lack of support, scarcity of grants and the need to travel internationally for short-term contracts that will likely take many years, if at all, to eventuate into a stable job. (21-30 year old)

> No longer enjoyed profession/burnt out. (31-40 year old)

> Changed interests. (31-40 year old)

> Personal circumstances, changed my mind on what I want to do, redundancy. (31-40 year old)

> Becoming a mum, makes it hard to maintain a research career which is field based. Also as you progress in career using science to influence decision making and policy becomes more appealing than doing the science. (31-40 year old)

> Science research is a terrible career for a woman. Have moved into communication and management as it is more friendly for work life balance. Better pay; less hours; more job satisfaction and job security. (31-40 year old)

> Not changed fields, but went from university research environment into industry because the research I did would have required moving overseas, most likely. Also changed for less lab work, for more money, and more "real" experience. (31-40 year old)

> Realised I didn't want to be an engineer. Really didn't want to be an engineer. (41-50 year old)

> Moved from Veterinary Surgeon into a pharmaceutical industry role for more consistent hours. (41-50 year old)

> Having children + change of location. (41-50 year old)

> My initial choice of career, which dictated my initial choice of degree, was based on my love of my chemistry teacher and the wish to be a skilled employee, ie professional qualifications. However, the interest in engineering waned during the course. Switching to another option to be a professional ie accounting and being employed in the chartered world, was done during uni and so I did not ever switch careers per se - but definitely the direction of my career path... (41-50 year old)

> Yes - Science to Finance. Really enjoyed science but my father is a science academic and my mother always said don't marry an academic, they don't make enough money. I liked it but didn't love it. Hence the change. (41-50 year old)

School choice to promote STEM interest for boys and girls (relates to Aims 4 & 5)

Towards the end of the survey, participants were asked to indicate their recommendations for school choice (single-sex, co-educational, or either – depends on the child) to provide for both a boy's and a girl's interest in STEM-related studies. The data were analysed separately for the full samples of female and male respondents.

Females' (all) recommendations

As can be seen from the data in Table 12, 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 12

School setting thought to promote STEM related studies for boys and for girls (all females)

	For boys		For girls	
Recommendation	**N**	**%**	**N**	**%**
Single-sex school	138	14	427	43
Co-educational school	98	10	79	8
Either, depends on the 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 13.

Table 13

Recommendation of school setting by respondents' own schooling

		School attended			
		Co-educational		Single-sex	
	Recommendation	**N**	**%**	**N**	**%**
To promote a boy's interest in STEM	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 in STEM	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 13 that a higher percentage of those who had 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. On the other hand, a higher percentage 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 ($\chi^2 = 30.09$, df = 4, $p<.001$).

A comparable pattern can be seen in Table 13 for promoting girls' interest in STEM. Of those who attended single-sex schools, a higher percentage nominated single-sex schools (48%) than co-

educational schools (5%) to promote a girl's interest in STEM. Of those who had attended co-educational schools, a higher percentage recommended co-educational schools (24%) than single-sex schools (18%) to promote a girl's interest in STEM. The different patterns nominated were statistically significant ($\chi^2 = 81.55$, df = 4, $p<.001$).

Also noteworthy are the smaller percentages of those attending both single-sex and co-educational schools who nominated "could be either" for girls (47% and 58% respectively) than for boys (77% and 72% respectively).

Respondents were also asked to provide the reason(s) for their choice of school setting to promote STEM interest for a girl and for a boy. For these analyses we focussed on the 164 females who had attended a co-educational school in their last year of schooling and on the randomly selected sample of 164 who had attended a single-sex school in their last year of schooling. The explanations of those whose recommendations for boys and girls differed were of particular interest. A selection of responses are shown below:

To promote a BOY'S interest in STEM	To promote a GIRL's interest in STEM
Attended single-sex schools	
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.
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.
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
Single-sex school	*Either, depends on child*
My brothers went to all boys schools and really loved it. Plus boys are hyped up on testosterone as is, let alone at that age, and I think it would help to focus them and/or remove the insecurities of having girls around	…. Girls are super bitchy at that age and maybe it would lessen the bitchiness if there were some guys around, or make it worse.

To promote a BOY'S interest in STEM	To promote a GIRL's interest in STEM
Single-sex school	*Co-educational school*
Some may feel a single-sex school environment will enhance their interest in STEM as the male population generally take up such related studies compared to women.	As boys have a stronger affinity towards STEM-related studies, it may influence girls' interest.
Attended co-educational schools	
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
Single-sex school	*Co-educational school*
Majority of the guys I studied with at university came from single-sex schools	Women need to be aware of the job opportunities outside the traditional options to encourage them to study STEM subjects. I found there was active discouragement from a number of parties that may have prevented me from pursuing STEM subjects. It was only because of my parents and select teachers that I was given the opportunity
Co-educational school	*Either, depends on child*
Girls are generally more motivated than boys, in co-ed school boys can be encouraged by the motivation of the female classmates.	[No explanation provided]
Co-educational school	*Single-sex school*
I think a boy would be able and encouraged to enter STEM-related fields regardless of the school. However, growing up and learning with girls could set their expectation that girls can, should, and do have an interest in, and aptitude for STEM subjects. Therefore no preconceived idea of women as greater or lesser in these fields on entering university/the workforce	I think that the old adage that boys benefit most from co-ed and girls from single-sex is probably true, unless the school works actively to foster a culture of equality and non-distinction between "girls" subjects and "boys" subjects.

Additional analyses for females who had attended SS schools

The responses of the females who had attended single-sex schools were also disaggregated by respondent age. Recommendations for school type to promote a girl's interest in STEM are shown in Table 14, and recommendations for boys in Table 15.

Table 14

Recommendations of school type for promoting a girl's interest in STEM-related studies, by respondent age (all females)

	Single-Sex		Co-ed		Either (depends)	
Age	**N**	**%**	**N**	**%**	**N**	**%**
18-20	28	48.3	7	12.1	23	39.7
21-30	107	54.0	7	3.5	84	42.4
31-40	82	46.6	3	1.7	91	51.7
41-50	75	46.3	5	3.1	82	50.6
51-60	65	47.8	10	7.4	61	44.9
61-70	25	34.7	7	9.7	40	55.6
Over 70	18	45.0	5	12.5	17	42.5
Total	400	47.5	44	5.2	398	47.3

As can be seen in Table 14, the 21-30 age group had the highest percentage recommending single-sex schools (54.0%) to promote girls' STEM interests, and the 61-70 age group had the lowest percentage (34.7%)

Table 15.

Recommendations of school type for promoting a boy's interest in STEM-related studies, by respondent age (all females)

	Single-Sex		Co-ed		Either (depends)	
Age	**N**	**%**	**N**	**%**	**N**	**%**
18-20	12	21.4	4	7.1	40	71.4
21-30	35	17.8	17	8.6	145	73.6
31-40	16	9.2	5	2.9	153	87.9
41-50	23	14.3	8	5.0	130	80.7
51-60	26	19.5	15	22.3	92	69.2
61-70	10	14.3	11	15.7	49	70.0
Over 70	6	17.1	6	17.1	23	65.7
Total	128	15.5	66	8	632	76.5

From Tables 14 and 15, it can be seen that the female respondents were considerably more likely to recommend either school type (depending on the child) to promote a boy's interest in STEM than to promote a girl's interest in STEM. At the same time, they were much more likely to recommend a single-sex school to promote a girl's interest in STEM than for a boy. It can be inferred from these findings that females' views are consistent with the widespread belief that single-sex schools are more likely than co-educational schools to promote a girl's interest in STEM.

Final Summary

The catalyst for the work summarised in this report came from interest expressed by the Alliance of Girls' Schools Australasia members in two main research areas:

> **overall academic and life outcomes for girls educated in single-sex schools** compared with girls educated in co-educational schools, measured by indicators including national/international testing results, tertiary entrance scores, level of post-school qualifications, occupation, wages and labour force participation
>
> **the engagement of girls from single-sex schools in STEM** (science, technology, engineering and mathematics) compared with girls from co-educational schools, as measured by participation in subjects such as advanced mathematics and physics at school, and/or the number of girls from single-sex and co-educational schools choosing to study STEM degrees at university and enter STEM-related careers, particularly in traditionally male-dominated areas such as mathematics, engineering, information technology and physical sciences.
>
> (Alliance of Girls' Schools Australasia Research Grant Guidelines 2016)

In our study, we aimed to address aspects of both research areas. To explore the issues we designed an online survey in which we aimed to:

1. compare STEM participation rates at school level and beyond for females who attended single-sex and co-educational schools, in different time periods (e.g., by decade), by school type attended (government and non-government), and by country (Australia and New Zealand);
2. identify and compare the life/career trajectories of these females;
3. identify systemic and/or personal factors facilitating or inhibiting STEM participation of these females; and
4. compare the above with responses from a male sample.

In addition we explored:

5. perceptions of single-sex or co-educational schooling to promote STEM for girls and boys.

Participants were recruited via Facebook and through communications with alumnae of member schools of the Alliance of Girls' Schools Australasia. Completion rate of the survey was high (for Australian participants). From this we infer that they considered the scope of the survey both important and relevant. While our particular focus was on females who had completed their final year of schooling (N=964) in single-sex schools, our sample also comprised females and males from co-educational schools (N=164 and N=58 respectively). The STEM school-level subjects we considered were: physics, chemistry, biology, information technology (IT), and three levels of mathematics subjects. Data contained in the body of the report confirmed that the people who responded to our online survey were indeed STEM-oriented individuals.

Using the aims listed above as headings, we summarise our main findings below.

1. Compare STEM participation rates at school level and beyond for females who attended single-sex and co-educational schools, in different time periods (e.g., by decade), by school type attended (government and non-government), and by country (Australia and New Zealand)

- The percentages of females in the sample from single-sex schools who studied each of the STEM subjects was higher than the percentages of the female 2015 VCE cohort who did so.
- The recruitment strategies adopted for the study resulted in a sample skewed towards STEM interest and/or STEM career involvement.
- Most (91%) of the female respondents attending single-sex schools had continued on to post-school studies.
- The decade of 1990-1999 was found to be the period in which the participants' enrolments in STEM-related school-level subjects were at a peak. In particular:
    - Biology: decreased after 1970-1979
    - Physics, Advanced mathematics, and IT/Computing: trended up until 1990-1999 then declined after that time
    - Chemistry and Intermediate mathematics: trended up until 1990-1999, then remained fairly steady
- The samples of female participants who completed their final year of schooling in single-sex and co-educational schools were very similar.
    - There were no major differences in the age profile of the two groups of females, nor between their profiles with respect to the decade of school completion
    - With respect to higher education and post-school qualifications, there was again no appreciable difference between the two groups. Both groups of females were well qualified compared with the Australian female population, with about 75% of each group having completed at least a bachelors degree, 17% a Masters degree, and around 7% a doctoral degree.

  Thus data from female respondents who attended a co-educational school serve as a useful context for comparative purposes.
- The vast majority of respondents had attended schools in the metropolitan capitals.

Note: For reasons explained in the body of the report, our data are restricted to those who attended schools in Australia.

2. Identify and compare the life/career trajectories of females who attended single-sex and co-educational schools

- A high proportion of respondents (around 80%) were in paid employment at the time of completing the survey.
- A higher percentage of females who attended single-sex schools than co-educational schools reported working in the health or allied health sciences (28%).
- A higher proportion of females from co-educational schools than single-sex schools reported working in Engineering. Recruitment bias may be a partial explanation of this. As discussed in the report, there were some respondents from single-sex schools who had studied STEM-related subjects in the final year of schooling but had not planned to pursue a STEM-related career path, or had been advised against this career trajectory.
- The different proportions of females from single-sex and co-educational schools in the health and allied health sciences and engineering may be related to the numbers studying

respectively biology and advanced mathematics, and physics, that is, subjects which are closely aligned to the recommended backgrounds for tertiary studies in the health and engineering field. *While acknowledging that science, technology, engineering and mathematics are invariably areas associated with STEM, the importance of STEM proficiency in other fields should also be fore-grounded.*

- For both females who attended single-sex and co-educational schools, being good at one or more STEM subjects, parents, and good employment prospects were the most important influences affecting their choice of initial career. While the ordering of the three most influential factors was the same for both groups, parents seemed to have a somewhat greater influence on those who had attended single-sex schools.
- While mentioned by many respondents, school-based influences such as teachers and career advice did not feature in the top three factors identified as influential, nor in the top three list of most influential factors.

3. Identify systemic and/or personal factors facilitating or inhibiting STEM participation of these females who attended single-sex and co-educational schools

- Obstacles mentioned most frequently were children and parenting responsibilities, self belief, and gender stereotyping.
- While mention of these barriers was not surprising from older participants, disappointingly, they were also cited by younger women
- About one-third of the group had changed career. The reasons for the career change mentioned frequently by the older participants were: personal circumstances, parenting, the impact of gender stereotyping, and issues associated with career opportunities.
- Younger respondent still nominated gender stereotyping but less frequently. Instead, they focussed on an opportunity for better remuneration, dissatisfaction with their (STEM-related) careers, and wanting a change or wishing to pursue other interests.

Note: The open-ended responses were coded by theme for a random sample of 164 of the 964 female respondents from single-sex schools.

4. Compare data with responses from a male sample.

Note: As explained in the body of the text, time and budget constraints limited the number of male respondents to the survey. Nevertheless, some useful between sample comparisons could be made.

- VCE 2015 data revealed that higher proportions of males than females studied physics, chemistry, specialist mathematics, mathematical methods, further mathematics, and the two IT subjects.
- Similarly, in the study sample, higher proportions of males than females reported studying physics, chemistry, advanced level mathematics, intermediate level mathematics, elementary level mathematics and IT in their final year of schooling.
- For both the VCE 2015 group and our sample, there were higher proportions of females than males who studied biology.
- Thus the pattern of gender differences in subject participation found for the 2015 VCE cohort was also evident in the enrolment data provided by the respondents to our survey.
- Common reasons for a career change put forward by male participants included natural progression/ better opportunities, or not liking their previous job as the reason for a career

change. In contrast to our female samples, none mentioned children or family responsibilities as the reason.

5. Perceptions of single-sex or co-educational schooling to promote STEM for girls and boys

- Many still considered that single-sex schools are more likely than co-educational schools to promote a girl's interest in STEM. 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.
- The school attended by the respondent influenced the preference of a single-sex or co-educational setting.
- For the full female sample, the younger respondents (the 21-30 year old group) had the highest percentage recommending single-sex school for girls while the older respondents (61-70) had the lowest percentage.

Implications of the findings

The sampling issues identified earlier in this report needed to be borne in mind when considering any implications of the findings in this study. A consequence of the sampling issues was that some of the comparisons encompassed in the aims listed above could not be conducted, while others that were undertaken were less robust than the ideal.

As noted above, the targeting of people with STEM-backgrounds to participate in the study was successful.

It was clear that the female participants from single-sex and co-educational schools were similar with respect to age and decades of school completion profiles, enrolment patterns in the STEM-related subjects in their final year of schooling (with minor variations), and they had similar post-school study profiles. However, it was found that a higher proportion of females from co-educational schools than from single-sex schools had completed engineering studies, while a higher proportion of females from single-sex than co-educational schools had completed studies in health-related fields (identified by the Chief Scientist of Australia as a STEM professional field). Perhaps related to this was the finding that the parents of those who had attended single-sex schools were identified more often as influences on career-related decisions than were parents among females who had attended co-educational schools. Are parents of girls in single-sex schools more likely to encourage girls into health-related areas than the hard sciences, including engineering? It would appear worthwhile exploring this issue further.

Another interesting finding was that school-based factors (teachers, career advice) were not found among the top three factors identified as influencing career decisions, nor were they in the top three listed “most influential” factors. Can, or should, teachers and careers advisors be more active in promoting STEM-related studies and career paths for female students?

The data about supporters and barriers of career trajectories were also informative. For the females (single-sex and co-educational backgrounds), but not for the males, the traditional gender stereotyped role expectations of females to serve as main carer for children were not only evident among older participants, but disappointingly also among younger respondents. These same gender stereotyped role expectations, as well as harassment/bullying in workplaces that are traditionally male dominated (e.g., engineering), also emerged as explanations for career changes. Clearly workplace cultures need to be addressed by those working in the pertinent fields. However, is there a role for schools to educate young women about their rights as employees in non-traditional fields, and how to report unacceptable incidents or practices in the workplace?

Overall, respondents considered single-sex schools more likely than co-educational schools to promote a girl’s interest in STEM. While about half of all female respondents thought that a single-sex school setting would promote STEM-related studies for girls, only about 14% thought this was the case for boys. Clearly the experiences of learning setting in which respondents had been educated had influenced their views on the issue. To promote a girl’s interest in STEM, the females who had been educated in a single-sex school (about 90% of the sample) were more likely to say single-sex than were the females who had been educated in a co-educational environment. It was of interest, however, that large proportions of respondents identified that either school setting would be appropriate depending on the child her(him)self. These findings augur well for children, that is, that the child is likely to be central in the decision about school type to attend.

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Appendices

Appendix A

Examples of Facebook advertisements used to recruit participants

Initial advertisement targeting Australian and NZ participants

Revised advertisement only targeting Australian participants

Variation of advertisement aimed at increasing Australian male participation rate

Appendix B

Copy of the online survey used in the study.

Default Question Block

Schooling, careers, and STEM
(Monash University Project Number: CF16/1318 2016000698)

This study is being conducted by:

Professor Helen Forgasz (Helen.Forgasz@monash.edu) and
Adjunct Professor Gilah Leder (Gilah.Leder@monash.edu).

By completing the survey, you are consenting to participate. It should take about 20 minutes to complete.

You are free to exit the survey at any time if you do not wish to complete it, and you do not have to answer questions you are uncomfortable about. Once you have submitted the questionnaire, you are unable to withdraw your responses.

Data collected will be stored on password controlled computers. Only members of the research team will have access to the data.

Aim of the study

For this study, we have accepted the view of the Chief Scientist of Australia that “studying STEM opens up countless job options”.

Our aim is to explore the impact of school setting (single-sex or coeducation) on females’ and males’ subject choices and their eventual career paths and occupations, with a particular focus on STEM (Science Technology, Engineering, and Mathematics). Of interest are the STEM subjects studied at school and post-school, and the wide range of occupations in which this knowledge is applied.

Findings from this study may be presented at conferences and in published journals and book chapters.
For further information about this project, contact the researchers via the email addresses listed above.

Complaints

If you have any concerns or complaints about the conduct of the project, contact the Executive Officer, Monash University Human Research Ethics (MUHREC):

Executive Officer
Monash University Human Research Ethics Committee (MUHREC)
Room 111, Building 3e
Research Office
Monash University VIC 3800
Tel: +61 3 9905 2052
Fax: +61 3 9905 3831
Email: muhrec@monash.edu

Thank you.

Helen Forgasz and Gilah Leder

Instructions

The survey is divided into several sections. Please complete each section.

In many cases you only need to select your response to a question from a given list of options. There are also some questions for which you are asked to provide an explanation.

When you have finished the survey, please click the “Submit” button.

Section A: About You

Are you:

- Male
- Female
- X (non-binary)

How old are you?

- 18-20
- 21-30
- 31-40
- 41-50
- 51-60
- 61-70
- Over 70

Section B: About your schooling

Did you complete your final year of schooling in

- Australia
- New Zealand
- Other Country

At that time, was this school:

- A Government school
- A Catholic school
- An Independent school
- Other - please explain

At that time, was this school:

- Public school
- Private school
- Other - please explain

In which year did you complete your final year of schooling?

At that time, was this school situated in a metropolitan (major city) area?

Yes

No

At that time, was this school

- co-educational
- single-sex boys
- single-sex girls
- Other – please explain

Which one or more of the following STEM subjects did you study in your final year of schooling (mark all those applicable)

- Advanced Mathematics
- Intermediate Level Mathematics
- Elementary Level Mathematics
- Physics
- Chemistry
- Biology
- Information Technology/Computing
- None of the above

Other subjects you studied in your final year of schooling - please list all

1

2

3

4

5

6

Please add any other information you believe is relevant about your final year of schooling (e.g. did final year of schooling part-time, left school early and returned, completed my schooling in a none traditional setting....)

Section C: About your post school education or training

Did you complete higher education studies at any time after your final year of schooling?

Yes ○ No ○

Which one, or more, qualifications did you complete?
For each provide the requested details.

- ☐ Certificate. Please specify (e.g. Certificate III in Drafting, Certificate 5 in Tourism)
- ☐ Diploma. Please specify (e.g., Diploma in Human Development)
- ☐ Advanced diploma. Please specify (e.g., Advanced Diploma of Oral Health)
- ☐ Bachelors degree. Please specify (e.g., Bachelor of Arts, Bachelor of Science)
- ☐ Graduate diploma. Please specify (e.g., Graduate diploma of Education)
- ☐ Graduate Certificate. Please specify (e.g., Graduate Certificate in Nursing)
- ☐ Masters degree. Please specify (e.g., Master of Engineering, Master of Business Administration)
- ☐ Doctoral degree. Please specify (e.g., PhD in Education, Doctor of Letters)
- ☐ Other

Please add any other information you believe is relevant about your post school education or training

Section D: About your work

Are you in currently in paid employment?

yes

No

Indicate which one of the following broad fields best fits with your current occupation

- Physical or biological sciences
- Agricultural, environmental, or related (science) studies
- Information Communication Technology / Computing
- Engineering
- Mathematics
- Health or allied health sciences
- Science/IT/Mathematics teaching at secondary or post-secondary level
- Other - please explain

Please provide more details about the specifics of your current occupation

If you have had a previous career/occupation please indicate which one or more of the following broad fields best fits with your previous employment.

- Not applicable
- Physical or biological sciences
- Agricultural, environmental, or related (science) studies
- Information Communication Technology / Computing
- Engineering
- Mathematics
- Health or allied health sciences
- Science/IT/Mathematics teaching at secondary or post-secondary level

- [ ] Other - please explain

Please provide more details about the specifics of your previous occupation(s)

Have you ever been in paid employment?

Yes	No
○	○

Indicate which one or more of the following broad STEM-related fields best fit with your previous occupation(s)

- [ ] Physical or biological sciences
- [ ] Agricultural, environmental, or related (science) studies
- [ ] Information Communication Technology / Computing
- [ ] Engineering
- [ ] Mathematics
- [ ] Health or allied health sciences
- [ ] Science/IT/Mathematics teaching at secondary or post-secondary level
- [ ] Non-STEM-related. Please explain
- [ ] Other - please explain

Please provide more details about the specifics of your previous occupation(s)

Factors influencing your original career paths

Which one or more of the following factors influenced your INITIAL career pathway?

- [ ] 1. Good at one or more school level STEM subjects (maths, science, IT)
- [ ] 2. Teachers

- [ ] 3. Career advice
- [ ] 4. Parents
- [ ] 5. Family members other than parents
- [ ] 6. Friends
- [ ] 7. Good employment prospects
- [ ] 8. Wanted to work in a STEM-related occupation or profession
- [ ] 9. Employer supported study
- [ ] 10. Other. Please explain

Which one of the 1-10 above was the MOST influential factor?

1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○

If you have changed careers, what were the main factors influencing your decision? (e.g., changed personal circumstances, redundancy, change of location etc.)

Perceived support and barriers

Who or what served to support you in your career path(s)/goal(s)?

Who or what served as barriers to your career path(s)/goal(s)?

Section E: Advice to others about schooling and interest in STEM

To promote a boy's interest in STEM-related studies, would you recommend:

- A single-sex school
- Co-educational school
- Could be either, depending on the child

Please explain your choice

To promote a girls' interest in STEM-related studies, would you recommend:

- A single-sex school
- Co-educational school
- Could be either, depending on the child

Please explain your choice

Please add any comments about single-sex or co-educational schooling and STEM related careers

Block 1

Please add any comments you may have about the survey, or add additional information you think is relevant about your schooling and career path.

Appendix C

Publications and presentations based on data gathered in the study

Publications completed and submitted, as well as other presentations, based on the data gathered in this research study, are listed below. Copies of pertinent papers follow.

Papers in refereed conference proceedings

Forgasz, H., & Leder, G. (2017). Gender and VCE mathematics subject enrolments 2001-2015 in co-educational and single-sex schools. 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). MERGA: Adelaide.

Forgasz, H., & Leder, G. (2017). Mathematics enrolments: Single-sex and co-ed. In B. Kaur, W. K. Ho, T. L. Toh, & B. H. Choy (Eds.), *Proceedings of the 41st conference of the International Group for the Psychology of Mathematics Education* (Vol. 1, p. 192). Singapore: PME.

Leder, G., & Forgasz, H. (2017). STEM and single-sex schools: What counts? In B. Kaur, W. K. Ho, T. L. Toh, & B. H. Choy (Eds.), *Proceedings of the 41st conference of the International Group for the Psychology of Mathematics Education* (Vol. 1, p. 230). Singapore: PME.

Papers submitted

Forgasz, H., & Leder, G. (2017). STEM enrolments at school and factors influencing career paths. *Alliance Magazine* (October issue).

Conference abstracts:

Forgasz, H., & Leder, G. (2017). Gender and VCE enrolments in mathematics subjects 2001-2015: Does school type matter? *WIMSIG conference 2017: Celebration of women in Australian mathematical sciences* (p. 61). Adelaide: University of South Australia.

Leder, G., Forgasz, H., & Zmood, S. (2017). From school to career: A snapshot of supports and obstacles. *WIMSIG conference 2017: Celebration of women in Australian mathematical sciences* (p. 62). Adelaide: University of South Australia.

Other

Forgasz, H., Leder, G., & Zmood, S. (2017). *Using Facebook for recruiting research participants*. [*Workshop presentation]*. 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* (p. 710). MERGA: Adelaide.

Forgasz, H., & Leder, G. (2016, April). Alliance funds new study on STEM participation. *In Alliance*, *56*, 6.

Forgasz, H., & Leder, G. (2016). *STEM enrolments in Victorian single-sex and co-educational schools*. Paper presented at the Australian Association of Research in Education annual conference, Melbourne. Retrieved from http://www.aare.edu.au/publications-database.php/10707/STEM-enrolments-in-Victorian-single-sex-and-co-educational-schools

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

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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.

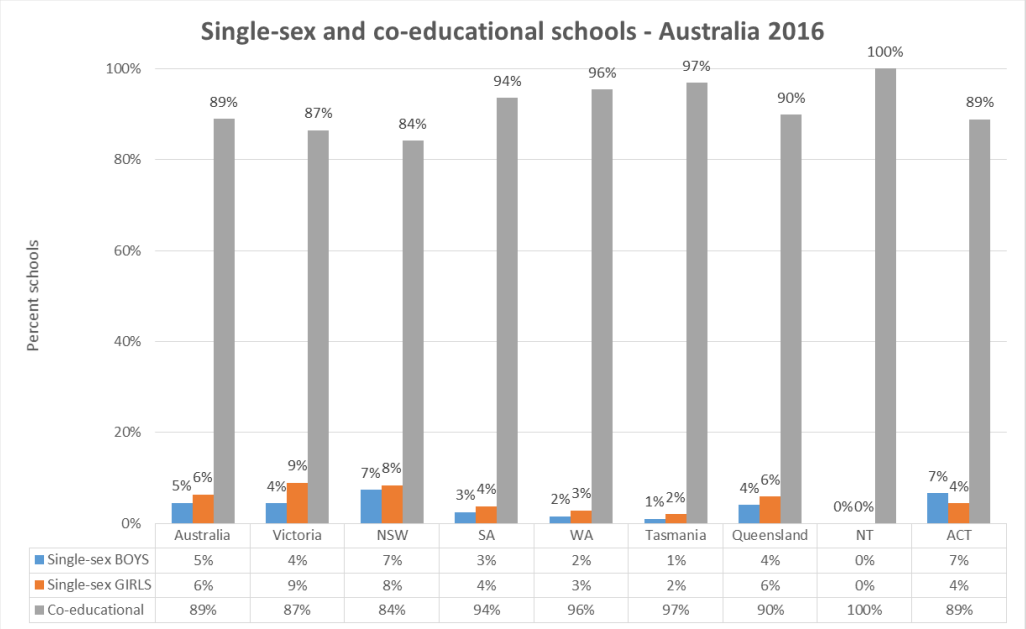


Figure. 1. Percentages of single-sex (boys/girls) and co-educational schools in Australia in 2016, by state/territory. [Data derived from https://www.goodschools.com.au/.]

(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.

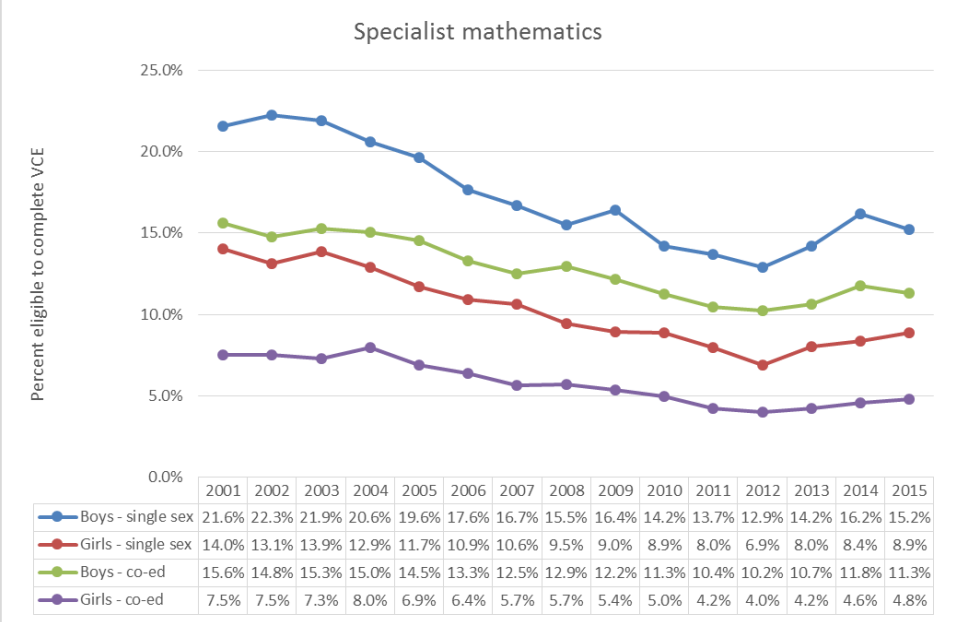
The survey data. The items in which survey participants were asked whether, to promote a boy's/girl's interest in STEM-related studies, they would recommend a single-sex school, a co-educational school, or neither (that it would depend on the child), were of particular interest for this article. Also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



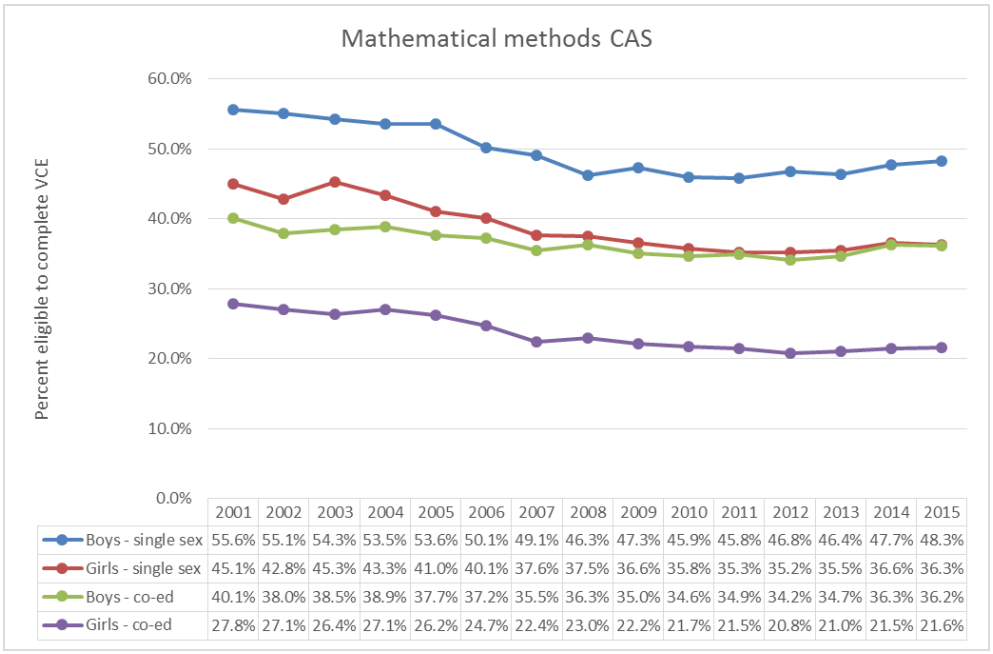
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Boys - single sex	21.6%	22.3%	21.9%	20.6%	19.6%	17.6%	16.7%	15.5%	16.4%	14.2%	13.7%	12.9%	14.2%	16.2%	15.2%
Girls - single sex	14.0%	13.1%	13.9%	12.9%	11.7%	10.9%	10.6%	9.5%	9.0%	8.9%	8.0%	6.9%	8.0%	8.4%	8.9%
Boys - co-ed	15.6%	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:

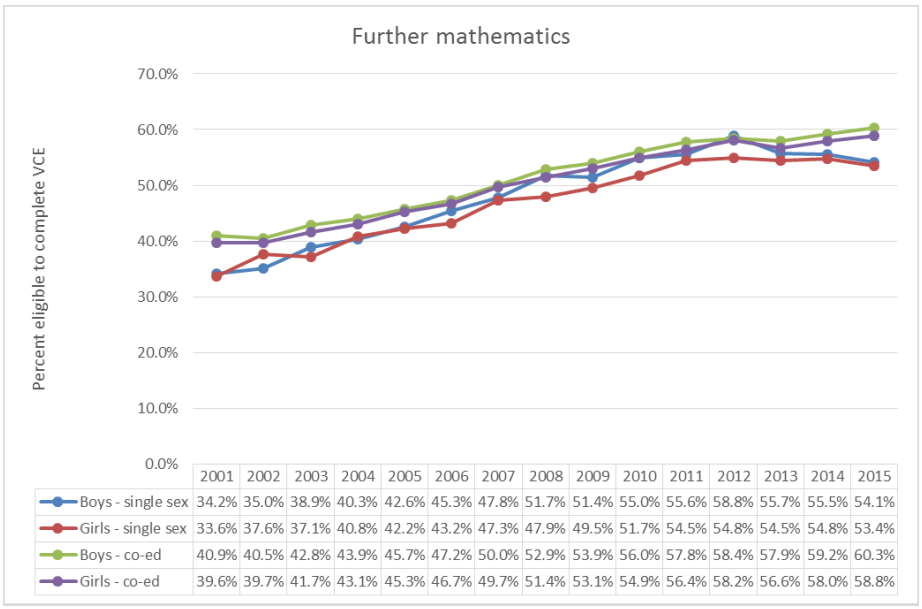
- A higher proportion of girls in single-sex schools than in co-educational schools study mathematical methods; the same pattern is evident among the boys.
- Higher proportions of students (both boys and girls) in single sex schools than in co-educational schools study mathematical methods (CAS)

- 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 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.	*Single-sex school* 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 Look at industry - males don't seem to need any consideration here - system seems to be working for men in STEM.	*Single-sex school* 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 Boys don't get told they are not good at maths or science so I think choice of school is not as important	*Single-sex school* 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 Each child learns differently and is to be nurtured for their individual learning style	*Single-sex school* 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

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MATHEMATICS ENROLMENTS: SINGLE-SEX AND CO-ED

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Single-sex schools flourish in a number of countries, including Australia (OECD, 2009) and have grown in popularity in others, for example, the United States (Pahlke & Hyde, 2016). Whether a single-sex or mixed (co-educational) school setting affects mathematics learning has generated much research, most often explorations of achievement outcomes. Participation rates in post compulsory mathematics courses, important determinants for entry into STEM-related tertiary studies and careers, have received less attention. Previous inconsistent research findings are attributed to various factors, including the paucity of evidence based studies. More research is clearly needed. We report enrolment data for grade 12 mathematics subjects gathered over 15 years in Victoria, Australia, a site with sufficient data for credible analyses.

Three mathematics subjects are offered at the grade 12 level: Advanced (A), Intermediate (I), and Elementary (E). Enrolments in these subjects were examined by school type and gender: single-sex boys (SSB), single-sex girls (SSG), co-education boys (CB), and co-education girls (CG). To enable comparisons, percentages of enrolments by school type and gender were calculated. Enrolment patterns revealed:

- For A, boys' enrolments consistently exceeded girls'. SSB had the highest enrolment (15.2% in 2015), followed by CB, then SSG, with CG having the lowest enrolment (4.8% in 2015). For all groups, enrolments initially decreased over time but since 2012 have shown a small annual increase.
- For I, the pattern of enrolment was SSB (48.3% in 2015), SSG, closely followed by CB, and then CG (21.6% in 2015). There have been minor fluctuations in enrolment since 2008, for all groups.
- For E, there has been a steady increase in enrolments over time, for all groups. There were only minor differences in the percentage of males and females enrolled, irrespective of school type.

In summary, it could be argued that a greater percentage of students in single-sex than in co-educational schools are engaged in mathematics (subject I), or that a higher percentage of boys than girls enrol in mathematics (subject A), or that school type has little effect on participation in mathematics (subject E). Clearly, factors other than school type alone, or student gender, influence mathematics enrolment numbers.

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STEM AND SINGLE-SEX SCHOOLS: WHAT COUNTS?

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In many countries females are underrepresented in STEM (Science, Technology, Engineering and Mathematics) fields (OECD, 2012). Differences in study areas selected by males and females also persist. It has been suggested (e.g., Cherney and Campbell, 2011) that single-sex [SS] schools enable females to develop the subject prerequisites and skills important in STEM fields. However, lack of control in research about SS schooling has confounded the evaluation of research outcomes. As part of a larger study about schooling, careers, and STEM, we explored if participants assumed that STEM-related studies are more strongly encouraged in SS than co-educational schools. Survey participants were asked whether, to promote a boy's/girl's interest in STEM-related studies they would recommend a SS school, a co-educational [CS] school, or neither - that it would depend on the child.

The survey sample comprised 1157 females, aged from 18 to over 70. Most had studied mathematics in their final year of secondary school: an advanced (N=377), or intermediate (N=472), or elementary (N=126) mathematics course. We aimed to explore *perceptions* about SS schools - specifically if they were thought to promote interest in STEM-related studies, whether such beliefs were held similarly for boys and girls, whether beliefs varied according to the type of school attended by respondents, and by the amount of mathematics respondents themselves had studied. Our findings included:

- For boys, 14% recommended SS, 10% CS, and 76% "depends on the child"; For girls, 43% recommended SS, 8% CS, and 49% "depends on the child"
- Type of school attended by respondents influenced their recommendation. Those who had attended SS were more likely to recommend SS; those who had attended CS were more likely to recommend CS (for both boys and girls)
- Level of mathematics course studied in the final year of school did not affect the recommendation made, but a higher proportion of those who had taken a mathematics course would recommend a SS for girls than those who had not.

Assumptions persist that, particularly for girls, SS schools assist STEM-related pathways. Well planned research is needed to test the efficacy of these expectations.

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STEM enrolments at school and factors influencing career paths

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We invited women and men interested in STEM-related fields to complete an online survey. As well as biographical data, and a range of questions related to school enrolments in STEM subjects (physics, chemistry, biology, IT, and three levels of mathematics subjects), questions about career paths were also included.

The sample of female respondents was as follows:

- Attended single-sex schools = 964 (85.5% of all female respondents)
- Attended co-educational schools = 164 (14.5% of the female sample)

The ages of the female respondents ranged from under 20 to over 70, and the decades in which school had been completed ranged from 1950-1959 to the present (2016).

In this article, we focus on the responses of those who had attended single-sex schools in their final year of secondary school. We examine their participation in STEM subjects by decade of school completion, and explore their responses to questions about factors influencing their initial careers, as well as factors that facilitated and hindered their career paths or goals.

To set the study in the contemporary context, we begin with an examination of female enrolments, and in particular those attending single-sex schools, in STEM-related Year 12 subjects that were offered in the Victorian Certificate of Education [VCE] in 2015 (see Figure 1).

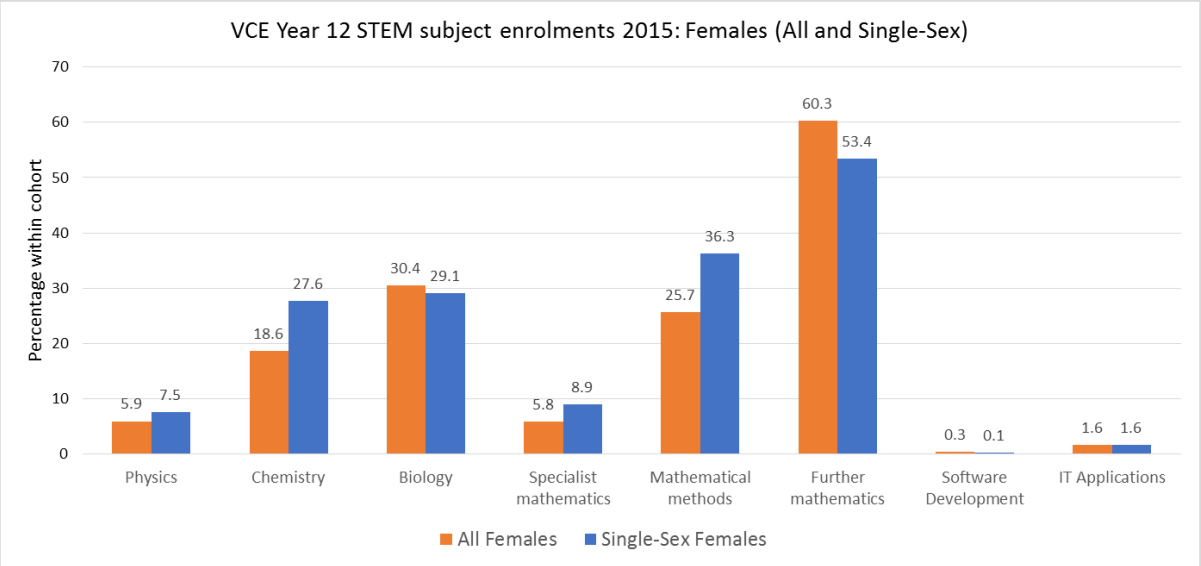

Figure 1. Female enrolments in Year 12 STEM-related subjects in VCE, 2015

The data in Figure 1 reveal that, in general, the percentages of females attending single-sex schools enrolled in the STEM-related subjects are higher than for all females in four subjects (physics, chemistry, specialist mathematics, mathematical methods CAS), lower in three subjects (biology, further mathematics, and software development), and the same in one subject (IT applications). It could be argued that the subjects in which there are higher percentages of females at single-sex

schools than for females overall are those which have the potential for higher study, and later career paths, in the physical sciences and engineering. The very low percentages of females in IT-related subjects is of concern.

In Figure 2 we show enrolment data in STEM-related subjects for the sample of females from single-sex schools from across Australia who completed the online survey. The data are presented by subject and by decade in which schooling was completed. [NB. The subject names for the three mathematics subjects are generalised to "advanced level", "intermediate level" and "elementary level" as defined by Barrington and Brown (2005)]. It is evident from our data that we successfully targeted people with STEM-backgrounds for our study. For example, from Figure 1 it can be seen that 7.5% of all Victorian single-sex females studied physics in 2015, and from Figure 2, that 23.4% of the single-sex female online survey sample from 2010-2015 indicated that they had studied the subject.

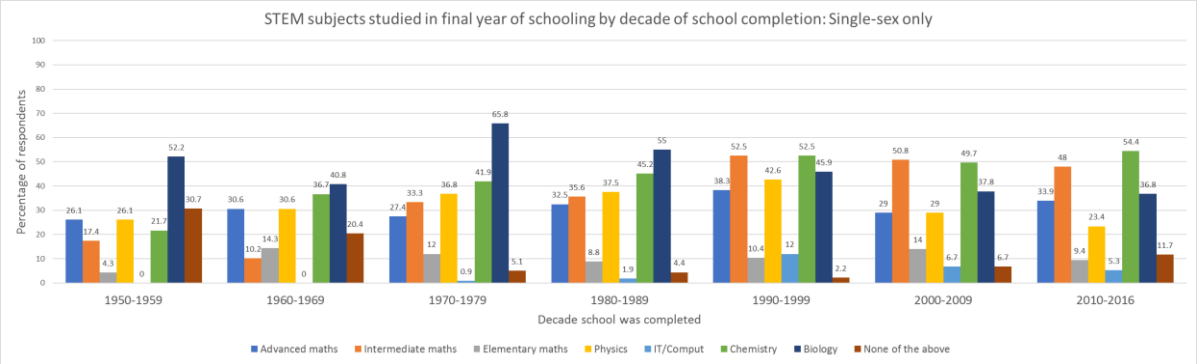

Figure 2. Single-sex female participants' STEM subjects studied in the final year of schooling by decade of school completion.

Interesting trends over time are also revealed in Figure 2.

a. Biology: steady decrease after 1970-1979
b. Physics, Advanced mathematics, and Intermediate mathematics: trended up until 1990-1999 then decline after that time
c. IT/Computing: also peaked in 1990-1999 (but low), then virtually disappears
d. Chemistry: trends up until 1990-1999, then remains fairly steady.

In summary, the decade of 1990-1999 appears to have been the period in which the participants' enrolments in STEM-related subjects were at a peak. The decade was one in which gender equity in educational outcomes was a priority. At the same time, following a national move in the late 1980s for Australia to have a common national curriculum rather than separate state curricula, major changes in the subject offerings and assessment regimes in the final years of schooling were in evidence. In Victoria, for example, the examination-based one-year Victorian Higher School Certificate was replaced with the two-year Victorian Certificate of Education, in which school-based assessments, as well as traditional timed examinations, contributed to final results. In 1990, the federal government developed the policy, *A fair chance for all: Higher education that's within everyone's reach*. Aims included an "increase in the proportion of women in non-traditional courses, other than engineering, from the current level to at least 40% by 1995 [and] an increase in the proportion of women in engineering courses from 7% to 15% by 1995" (Australian Bureau of Statistics [ABS], 2004). Between 1988 and 1992, it was reported that "the proportions of women enrolled in non-traditional courses increased" (ABS, 2004) and that "although there has been some movement of women into non-traditional courses, male students have continued to make

conventional choices" (ABS, 2004). The impact of these efforts may partially account for the increased enrolments in STEM-based subjects during the decade.

Factors influencing initial career path

Our survey respondents were asked to indicate which one or more, from a provided list of factors, were influential in their initial career pathways. They were also asked to identify which one of these was the most influential. Participants' responses are shown in Table 1.

Table 1.

Factors influencing initial career pathways (single-sex and all females)

	All females		Single-sex			
	Influences		Influences		Most influential	
Factor	**N**	**%**	**N**	**%**	**N**	**%**
Good at ≥1 STEM subjects	435	38.5	362	37.6	157	19.1
Teachers	326	28.9	281	29.1	64	7.8
Career advice	263	23.3	225	23.3	55	6.7
Parents	482	42.7	418	43.4	152	18.5
Other family	136	12.1	119	12.3	26	3.2
Friends	155	13.7	130	13.5	27	3.3
Good employment prospects	364	32.3	307	31.8	107	13.0
Wanted to work in STEM occupation	205	18.2	176	18.3	79	9.6
Employer support	48	4.3	40	4.1	9	1.1
Other	269	23.8	224	23.2	147	17.9

From Table 1 it can be seen that for females who had attended single-sex schools, parents were mentioned most frequently as influential in career direction (43.4% of respondents), followed by being good at one or more STEM subjects (37.6%), good career prospects (31.8%), and teachers (29.1%). When asked to select the most influential factor, being good at one of more STEM subjects was selected most often (19.1%), followed by parents (18.5%), and good employment prospects (13.0%). While mentioned frequently, school-based influences such as teachers and career advice did not feature in the top three most influential factors.

The increase in the participation in Physics, Advanced mathematics, and Intermediate mathematics until the decade 1990-1999, was highlighted above. When we examined the data in Table 1 more closely for participants completing school in the decades 1980-1989, 1990-1999, and 2000-2009, we noted some minor, but interesting, variations. For those from the 1980s and the 2000s, parents were selected as the most influential factor (17.1% and 19.3% respectively) for choice of the initial career path, while in the 1990s, 'being good at the subject' was identified as the most influential factor (24.9%). One interpretation of this finding is that the emphasis on "girls can do anything", that was part of the feminist agenda of the late 1980s and into the 1990s and was also highlighted in the popular media, had made its mark. In 1988 in Victoria, for example, there was an advertising campaign, *Maths multiplies your choices,* that was aimed at parents. It featured the slogan "Don't pigeon-hole your daughters" (see McAnally, 1991). An evaluation of the campaign revealed that females' enrolments in Year 11 mathematics increased dramatically in the following year. The success of the campaign resulted in funding being withdrawn, as there was a sense that the 'girl problem' had been solved. Thus, that enrolments in STEM subjects among the survey participants were higher in the 1990s may partially be explained by the social context of the times, resulting in a greater level of self-confidence among young women, while simultaneously challenging the

dominant stereotype of girls not being good at, or suitable to pursue studies in, mathematics and science.

On the survey, participants were also asked to describe who or what had supported and/or hindered their careers. The open-ended responses were coded by theme for a random sample of 164 of the 964 female respondents from single-sex schools. The results are shown in Figures 3 for supporting factors and Figure 4 for factors that served as hindrances. [NB. For each question, some respondents mentioned more than one factor, hence percentages do not add to 100%]

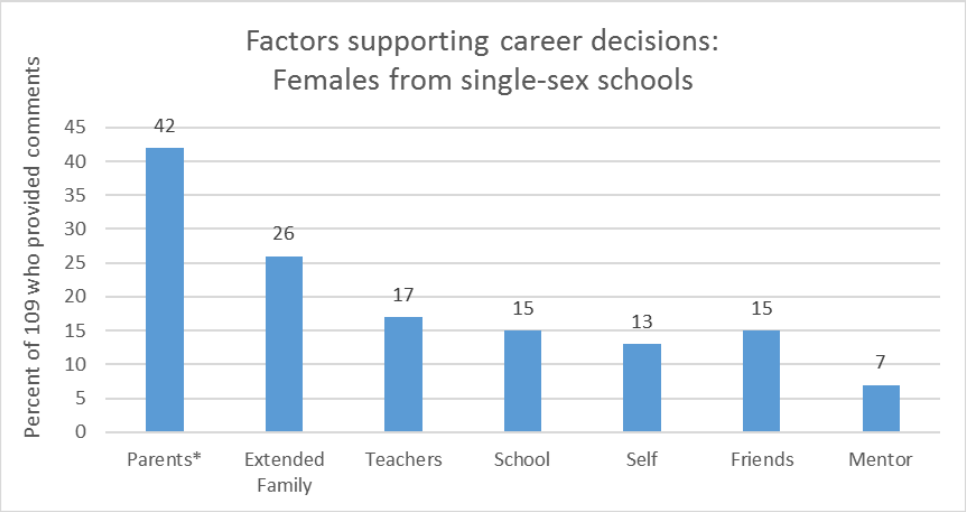

Figure 3. Factors supporting career decisions

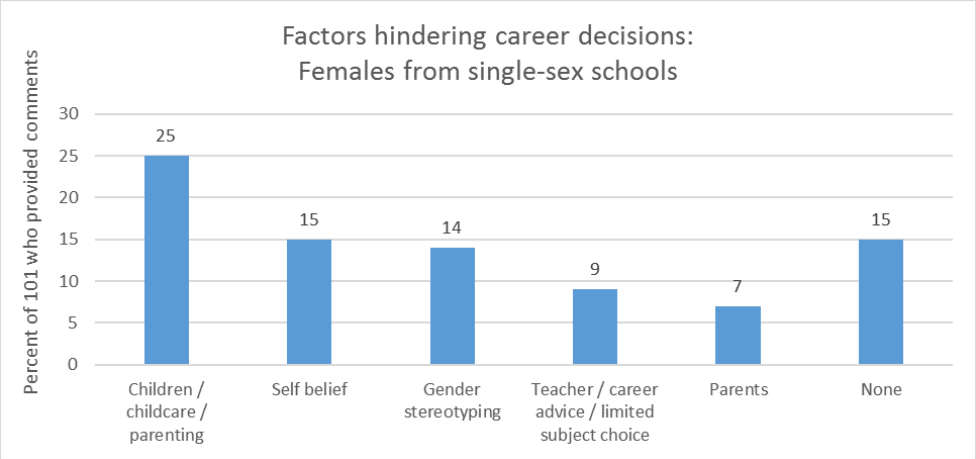

Figure 4. Factors hindering career decisions

As can be seen in Figure 3, supportive factors cited most frequently by the participants were parents (42%), extended family (26%), and teachers (17%), while obstacles mentioned most frequently were children and parenting responsibilities (25%), self belief (15%), and gender stereotyping (14%) - see Figure 4. While mention of these barriers was not surprising from older participants, disappointingly, they were also cited by younger women. That some respondents indicated that they had not experienced any particular hindrances is noteworthy, so too was the dual impact of parents and self belief (supportive according to some but cited as a hindrance by others).

Final comment

What might we learn from the findings we have reported in this article? Clearly, females in single-sex schools are enrolling in STEM related subjects in their final year of schooling in good numbers. Completing these subjects can lead to STEM careers. However, career obstacles faced by females decades ago appear to persist to the present time.

Being good at STEM subjects, parents' encouragement, and employment prospects all play an important role in encouraging career choices. Surprisingly, teachers and career advice seem to play a less important role. Should this be of concern?

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Gender and VCE enrolments in mathematics subjects 2001-2015: Does school type matter?

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In Australia, there are ongoing concerns about declining enrolments in mathematics, and in females' under-representation in mathematics and science studies and related careers.

On a regular basis, the relative benefits of single-sex or co-educational schooling are debated in the public sphere, with passionate supporters on both sides. There is a widely held belief that single-sex schooling has distinct advantages for girls in general, and for the study of science and mathematics, in particular. At the same time, co-educational schooling is viewed as beneficial for boys.

In Australia, in the government sector of education, entry into single-sex schools is generally selective, based on academic achievement. It is in the fee-paying sectors of education that single-sex schools predominate. In general, students attending non-government schools have higher socio-economic backgrounds than students attending government schools.

The literature is equivocal about the benefits of single-sex settings for girls with respect to achievement and attitudes towards mathematics. Little is known about the mathematics enrolment patterns for boys and girls attending single-sex and co-educational schools. If single-sex schooling does indeed favour girls' likelihood to study and succeed in the maths/science fields, is this apparent in enrolment patterns in grade 12 mathematics? In this paper we explore the enrolment patterns in the three Victorian Certificate of Education mathematics subjects offered at the Grade 12 level for girls and boys attending co-educational and single-sex schools over the time span 2001-2015. We also report on survey responses from adult females on their views of whether single-sex or co-educational schools will best serve boys and girls interested in STEM studies.

The data reveal that for Specialist Mathematics, there are higher proportions of boys than girls in both single-sex and in co-educational schools enrolled. While 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. For Mathematical Methods CAS, higher proportions of both girls and boys in single-sex schools than in co-educational schools were enrolled. For Further Mathematics, the proportions of students enrolled was virtually identical for boys and girls in both school types.

Considering that the same proportions of boys and girls in both school types were enrolled in further mathematics, it is simplistic to conclude that the gendered settings of schools alone contribute to the differences found for the other two mathematics subjects. Explanations by a well-educated group of adult females we surveyed on their reported preferences for a single-sex or co-educational school to promote STEM-related subjects for girls and for boys suggest that personal histories play a part. There was evidence that the belief that girls, more often than not, benefit from attendance at a single-sex school persist.

From school to career: A snapshot of supports and obstacles

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Abstract

Drawing on data from a larger study on schooling, careers, and STEM, we focus on students who attended a co-educational school in Australia. To achieve a national sample efficiently and within a limited budget, we relied primarily on Facebook for recruitment. Financial and time constraints dictated the length of the data gathering period.

The sample of interest for this presentation comprised 164 females and 58 males, aged 18 years and over. The majority of those who completed their schooling in 2009 or earlier were in paid employment when they completed the survey: 86% of the males and 83% of the females. As anticipated from the content of the Facebook "advertisement", many participants indicated that they had completed an advanced or intermediate mathematics course: 43.7% and 43.2% respectively had done so. Other subjects with a substantial participation rate by this group were chemistry (48.6%), physics (39.6%), and biology (34.7%). These participation rates are high compared, for example, to the participation rates in comparable VCE [Victoria Certificate of Education] STEM subjects. In our sample – as in state and national cohorts – more males than females completed intermediate mathematics, physics, and chemistry; proportionately more females than males completed biology and elementary mathematics. However, the gender difference in participation in advanced mathematics consistently reported in state and national data was not replicated in our sample: the proportion of males (44.8%) and females (43.3%) enrolled in advanced mathematics was very similar.

In the remainder of the session we present quantitative and qualitative data on the factors which influenced the males and females in their choice of initial careers, on the factors cited as supports or barriers for their chosen career path(s), and on elements which determined a change in career. We focus on personal and environmental issues, and examine whether perceptions of barriers have changed over time. Differences in the factors nominated by these STEM-oriented females and males as career path obstacles are identified and highlighted.

Workshop Sessions

Workshop sessions were held for 40 minutes on 3rd July 2017. The nine workshops and presenters are listed below.

Title	*Presenter(s)*
1. Using Qualtrics to design an online survey	Hazel Tan
2. Using Facebook for recruiting research participants	Simone Zmood, Gilah Leder, Helen Forgasz
3. Building an online presence: Sharing resources, exchanging ideas	Catherine Attard
4. Thesis examination: Similarities and differences from journal article and conference paper reviewing	Merrilyn Goos
5. Beyond scholarly journals: Why inform the profession and the general public	Kevin Larkin
6. Engaging teachers of mathematics in professional growth	Doug Clarke, Barbara Clarke
7. Reviewing for MERGA conference papers	Tom Lowrie
8. International Mathematical Modelling Challenge: An Australia perspective (2017)	Jill Brown, Peter Galbraith, Trevor Redmond, Gloria Stillman, Luke Bohni
9. Building a track record in readiness for major grant writing	Jane Watson

(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* (p. 711). Melbourne: MERGA.

ALLIANCE FUNDS NEW STUDY ON STEM PARTICIPATION

The low levels of participation in Science, Technology, Engineering, and Mathematics [STEM] are of continuing concern. Governments have recognised that a nation's future prosperity relies on a workforce and citizenry well-versed in STEM-related knowledge, skills, and creativity. For a range of reasons, females in Australia and New Zealand are not as engaged in STEM fields as males. Gender equity considerations are thus enmeshed in the debate on how best to achieve greater STEM involvement. School learning contexts – single-sex or co-educational – also enter the debate on STEM participation in schools.

A new study has been funded by the Alliance of Girls' Schools Australasia. With a focus on STEM, an important aim of the study is to monitor and track the impact of school setting (single-sex or co-educational) on females' subject choices and eventual career paths. To put these findings in context, comparable data will be gathered from males.

Data will be sought from former school students who completed their final year of schooling from 1970 to the present. An advertisement will be placed on Facebook to recruit participants from across Australia and New Zealand. Those replying will complete a carefully constructed online survey. They will be asked to provide biographical information, school type attended, educational background data including subject choices, and to describe their career trajectories. For older respondents, questions will be asked about the schooling options offered to their offspring and why this may have been similar to, or different from, their own.

It should be pointed out that publicly available sources on subject choices and career pathways are not reported separately for students attending single-sex or co-educational schools. Given this official lack of data, selective anecdotal evidence is often used as source material in the media to persuade audiences of the veracity of claims. This new and important study should provide trustworthy data to fill the void.

Alumnae of Alliance member schools will be able to participate in the online survey and contribute to the research study. We will publicise the details when they become available. ▲

HELEN FORGASZ

Helen is a professor of education in the Faculty of Education, Monash University. Her research interests include gender and equity issues in mathematics education, the affective domain, learning settings, and numeracy across the curriculum. Helen has published widely in scholarly and professional journals, and has co-edited several monographs on gender issues and mathematics learning. She serves on the editorial boards of high quality journals and book series and continues to be an active member of mathematics education research associations nationally and internationally.

GILAH LEDER

Gilah is an Adjunct Professor at Monash University and Professor Emerita at La Trobe University. Her research has focussed particularly on gender issues in mathematics education, on exceptionality – predominantly high achievement, and on the interaction between learning and assessment. She has published widely in each of these areas. She is a past president of the Mathematics Research Group of Australasia and of the International Group for the Psychology of Mathematics Education, and a Fellow of the Academy of the Social Sciences in Australia. She was awarded the Felix Klein medal for outstanding lifetime achievements in mathematics education research and the MERGA Career Research Medal.

STEM enrolments in Victorian single-sex and co-educational schools

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There is increasing concern about Australian workforce participation in Science, Technology, Engineering and Mathematics [STEM] (e.g., Office of the Chief Scientist, 2016). In particular, the need to encourage an increase in female participation in STEM has been flagged (e.g., Office of the Chief Scientist, 2013). The Office of the Chief Scientist (2013) provided descriptions of the fields of study encompassed by the acronym STEM (Science, Technology, Engineering and Mathematics). The Victorian year 12 VCE subjects consistent with these descriptions include: the three mathematics subjects (Specialist Mathematics, Mathematical Methods, and Further Mathematics), Physics, Chemistry, Biology, and the two Information Technology subjects (IT applications, and Software Development).

It is a widely held belief that girls are more likely to study STEM subjects in single-sex than co-educational schools. Logically, later participation in STEM-related studies and careers should follow. However, in an analysis of Australian Longitudinal Surveys of Australian Youth [LSAY] data gathered in 2009, Sikora (2013) reported that "Girls in girls-only schools are more likely to take up physical science subjects than their female counterparts in coeducational schools. However, single-sex schooling does not affect the likelihood of girls planning a physical science career" (p. 3). In a relatively small recent study in the USA, the authors also concluded that "gendered or other types of school environments do not seem to increase female participation in these [STEM] types of careers" (Cherny & Campbell, 2011, pp. 722-723).

In this paper we report large scale data not readily available publicly: enrolments in year 12 Victorian Certificate of Education [VCE] STEM subjects for males and females in single-sex schools, and in co-educational schools. Our aim was to explore the patterns of enrolment in the VCE STEM subjects over time (2000-2015). In this presentation, we will discuss the patterns of enrolment by sex over time for students in co-educational and single-sex settings.

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