THE UNIVERSITY OF MELBOURNE

FACULTY OF BUSINESS & ECONOMICS

Melbourne Institute Working Paper Series

Working Paper No. 24/16

The Attitudes of Boys and Girls towards Science and Mathematics as They Progress through School in Australia

Chris Ryan

MELBOURNE INSTITUTE® of Applied Economic and Social Research

The Attitudes of Boys and Girls towards Science and Mathematics as They Progress through School in Australia*

Chris Ryan
Melbourne Institute of Applied Economic and Social Research, The University of Melbourne; and ARC Centre of Excellence for Children and Families over the Life Course

Melbourne Institute Working Paper No. 24/16

ISSN 1447-5863 (Online)

ISBN 978-0-73-405221-6

August 2016

* Disclaimer: The research in this paper was commissioned by the Victorian Department of Education and Training. The findings and views in this paper are those of the author and should not be attributed to the Department of Education and Training. Contact: <ryan.c@unimelb.edu.au>.

Melbourne Institute of Applied Economic and Social Research
The University of Melbourne
Victoria 3010 Australia
***Telephone* (03) 8344 2100**
***Fax* (03) 8344 2111**
***Email* melb-inst@unimelb.edu.au**
***WWW Address* http://www.melbourneinstitute.com**

Abstract

Differences between boys and girls in their attitudes towards mathematics are apparent among students in Year 4 in Australia. While not more engaged in their classes, boys indicate that they like mathematics and are more confident about their ability in it than girls. These differences increase between Year 4 and Year 8, while differences in similar directions in reported attitudes towards science develop. In Year 8, these differences in attitudes exist across all school sectors, social backgrounds and student levels of achievement, aspirations about future levels of completed education, language backgrounds and the genders of their teachers. These differences at Year 8 exist within schools, not between schools of different types or who cater for different types of students. There appears to be one exception to this statement: girls in single sex schools are more likely to like and be as confident about mathematics and science as boys in single sex schools.

Keywords: Gender attitudes, science, mathematics, achievement

JEL classification: I29, J71

1. Introduction and motivation

While women's educational attainment has increased substantially in Australia since the second World War, they remain under-represented in Science, Technology, Engineering, and Mathematics (STEM) courses in higher education and in STEM-related occupations in the workforce (Roberts 2014). For example, 28% of the employed STEM-qualified Australians aged 15 years and over were female in 2011, with this figure just 14% in engineering. Just one-third of tertiary qualifications awarded in STEM fields in 2011 went to Australian women (Healy *et al*. 2013). Participation of girls in the gateway discipline of mathematics at school is low. Only 6.6% of all female Year 12 students in Australia in 2013 studied an advanced level mathematics subject, while 17.5% took intermediate level mathematics in the same year, participation rates lower across the board than for their male peers (Roberts 2014). These low participation rates are not unique to Australia, but reflect the situation in other developed countries (Hill, Corbett and Rose 2010, Roberts 2014, Organisation for Economic Co-operation and Development – OECD - 2015).

The reasons why girls may not participate in mathematics and science courses in senior schooling and in these subjects and engineering in post-secondary education are complex and reflect social, educational and economic factors, among others. Concerns exist that negative attitudes towards mathematics and science among girls may develop quite early in their schooling. This research aims to establish how different girls' attitudes are from those of boys in both Years 4 Year 8 to determine how large such differences are and how early any differences in attitudes develop.

Why do attitudes towards science and mathematics matter? In part, the attitudes matter because they shape later behaviour and provide a partial explanation for differences in STEM participation in post-secondary education. Among two cohorts of 15 year old students from the mid-2000s, around 7% of the girls and 12% of the boys later commenced courses in STEM at university. Using the relationships between participation in STEM and achievement in reading, mathematics and science, SES and attitudes toward science and mathematics, if the girls had had the same attitudes at fifteen towards mathematics and science as the boys, they would have made up more than a quarter of the gap in later STEM participation. So, attitudes towards STEM revealed by 15 year olds matter, in terms of later STEM participation, independent of actual achievement in mathematics and science.[1] Salvi Del Pero and Bytchkova (2013) find similar results, in terms of the role of attitudes at age 15 years on subsequent study, for other countries as well as Australia.

This paper documents the relationships between student confidence about their performance in and other attitudes towards mathematics and science and their actual achievement for boys and girls. It looks at whether these relationships change between primary and secondary school and how different the relationships are between attitudes and actual achievement in mathematics and science from that of reading, at least at primary school.

To study these questions, the paper uses Australian data from two international studies: the Trends in International Mathematics and Science Study (TIMSS) for 2007 and 2011 and the Progress in International Reading Literacy Study (PIRLS) 2011 survey (see Thomson *et al*. 2008, Thomson *et al*. 2012a, 2012b). The results indicate that small differences in attitudes towards mathematics and science between boys and girls in Year 4 open up substantially by the time students reach Year 8. These differences are widespread, existing across the social background distribution and most demographic characteristics. They also seem to exist in most types of schools. Within mathematics and science, boys tend to be more confident about and value more highly mathematics over science, while girls tend to prefer science, except for girls in single-sex schools, who like mathematics more than do boys in single-sex schools.

The remainder of the paper is organised as follows. The next section contains a review of the relevant literature on attitudes towards STEM. Section three contains descriptions of the methodology and the data used here, while section four contains the results. Concluding comments are made in section five.

2. Literature on student attitudes to STEM

Roberts (2014) notes that there are many factors that contribute to the under representation of women in mathematics and other STEM fields in education and employment. These included the nature and organization of STEM fields of study and

---

[1] This analysis used the 2003 and 2006 Programme for International Student Assessment (PISA) which focussed on mathematics and science respectively, which in Australia is linked to the Longitudinal Surveys of Australia Youth (LSAY). Subjects in LSAY are surveyed every year until they reach their mid-twenties.

employment. Further, the balance between work and family demands, and the extent to which this is accommodated within the workplace, was also problematic for young women. Roberts (2014) also argued that there are important social factors, ideas held by parents, teachers and others within the community, that impact female engagement in mathematics and other STEM fields. These social factors include: stereotypical viewpoints about the nature of STEM careers and their treatment as male domains versus other areas viewed as female, lack of encouragement from teachers and parents to pursue careers in STEM and the small pool of female role models in STEM areas (see also OECD 2015).

Research seeking to identify the determinants of gender disparities in the labour market and other areas of western societies has focused on three main sets of contributing factors: labour market operations and features of educational institutions that incorporate both explicit and implicit forms of exclusion, segmentation and discrimination; social norms and the behaviour of key advisers, including parents and teachers, that shape gender identity and acceptance of stereotypes; and gender differences in personality, including but not limited to ability (Hill *et al*. 2010).

The first of these explanations attributes the absence of women in certain professions to overt and/or unintentional discrimination, along with structural features of labour markets such as inflexible hours and short- and long-term "penalties" on maternity leave, which act as barriers facing women who have or plan to have children (Goldin and Katz, 2012). The second explanation maintains that different attributes that society inculcates in men and women shape gender patterns of behaviour, views on appropriate careers for men and women, and occupational choice (Gneezy *et al*., 2009). The third set of factors focusses on apparent differences in mathematical achievement between the genders in childhood and adolescence as a key filter that drives male dominance in STEM fields (Sells, 1973). Early research in this vein focused on the gap in average achievement in mathematics between boys and girls, while the emphasis on later studies has been that the under-representation of females in STEM fields arises because they are under-represented at the high end of the distribution of achievement (Hedges and Nowell, 1995; Pope and Sydnor, 2010).

In this paper, the focus is on the second set of explanations, involving the role of social norms, but we first say a little about the other two. Since this paper looks at the attitudes of school children, the experience of the labour market in shaping attitudes is likely to be less than the role of social norms. Of course, school age children do have views about their future that extend to the labour market. Roberts (2014) argues that by 15 years of age, the career ambitions of male and female students have already shaped their STEM engagement. Roberts

(2014) reports that in the 2006 round of PISA tests, approaching 30% of female and male participants in Australia expected to be in a science-related career by 30 years of age. However, this varied markedly between computer sciences and engineering on the one hand, and health sciences and nursing on the other. As many as 46% of the boys tested in PISA 2006 indicated an expectation of a career in computer sciences and engineering, compared with just 8% of girls. Despite this pattern, in general the occupational expectations of young Australians are significantly less gender-segregated than the labour market they eventually enter (Sikora and Saha 2011). Since these expectations precede participation, they must be based on views informed by social norms and stereotypes, so it seems most informative to focus instead evidence about the timing of the formation of these phenomena, which is the course we follow below.

On the role of differences in ability (or its proxy, achievement), Justman and Mendez (2016) study girls' participation in STEM subjects in the Victorian Certificate of Education Year 12 studies, conditional on students earlier achievement in Years 7 and 9 mathematics, as measured in NAPLAN. Justman and Mendez (2016) find that male over-representation in physics, information technology and specialist mathematics is driven by differences in the propensity to study those subjects, not by any differences in distribution of prior achievement in mathematics, while female over-representation in biology and health and human development was also driven by differences in the propensity to study those subjects. Nor did Justman and Mendez (2016) find support for the comparative advantage hypothesis: boys and girls who did well in both numeracy and reading choose STEM subjects more frequently than those who did well only in numeracy. They concluded that the gendered patterns of specialization observed in Year 12 arose from social norms and economic factors.

For New South Wales, Marginson *et al*. (2013) found that in 2011, only 18.6% of boys continued STEM subjects into their final year, compared with only 13.8% of girls. Disciplinary gender divergence consistent with the Victorian patterns was also apparent in NSW, with girls tending to choose biology or psychology in preference to physics or chemistry, and tending to choose either basic or intermediate level mathematics over advanced level subjects.

Herbert and Stipek (2005) reviewed the United States literature on when gaps in attitudes towards mathematics open up between boys and girls and concluded it occurred during primary school. In their own study, Herbert and Stipek (2005) found that girls' confidence about their mathematics skills were lower than boys from the third grade, even though there were no gender differences in achievement or in teachers' ratings of children's mathematics skills at that age.

In the analysis that follows later in this paper, we condition attitudes on student achievement. Hence, we study attitudes between boys and girls of the same level of achievement to remove one source of potential difference. This conditioning is important and allows us to focus on real differences between the genders. For example, Hill *et al*. (2010) consider the role of self-assessed abilities as an area where stereotypes can negatively affect girls' interests in pursuing careers in STEM – that compared to boys with the same level of actual achievement, girls assess their mathematical abilities as being lower. Further, they compare themselves to higher standards, resulting in few aspiring to careers in STEM areas. Where there are actual underlying differences in skills than might be important in STEM field, such as spatial skills, any skill deficiencies can be quickly and effectively addressed with training (Hill *et al*. 2010).

Bertrand (2011) reviewed the role of gender differences in psychological attributes, personality traits and gender identity in explaining gender differences in job choices and remuneration. The psychological attributes she looked at included risk aversion, attitudes toward competition, social preferences in the sense of attitudes towards redistribution, preparedness to negotiate and the role of the "Big Five" personality traits.

The review by Bertrand (2011) involved summarising relevant lab-based experiments on the psychological attributes with related evidence from empirical studies on the broader population. Croson and Gneezy (2009) and Eckel and Grossman (2008) both conclude that experimental findings are consistent with women being more risk averse than men. These studies often involve men and women choosing between different gambles that elicit their preparedness to take risks (Levin *et al*. 1988, Holt and Laury 2002, for example). Related to the gender gap in risk aversion is a gender gap in overconfidence (the latter may explain part of the former). Both genders tend to overconfidence, but men are more so relative to their ability (Lundeberg *et al.* 1994). Such results matter because Bonin *et al*. (2007) demonstrate that in the real world, individuals who are less willing to take risk sort into occupations with more stable earnings, which also tend to pay less on average (a compensating wage differential story – people trade earnings stability for lower wages).

Since many high profile, high earnings occupations operate in highly competitive settings where winners are rewarded disproportionately to losers, women may be under-represented in such occupations if their appetite for competition differs from men. Contested evidence is consistent with women, on average, systematically underperforming relative to men in competitive environments (Gneezy *et al*. 2003, Nierderle and Vesterlund 2007). Once more related to overconfidence, Nierderle and Vesterlund (2007) find that men overestimate their performance rank within the group they make comparisons over more than do women.

Other evidence, from both laboratory and field experiments, points to women having social preferences that are more redistributive than those of men and to be more altruistic, which might lead them to be less willing to compete or negotiate than men (Croson and Gneezy 2009 and Eckel and Grossman 2008b). Other papers point to women being more supportive of public spending in social policy areas than men.

Evidence on attitudes towards negotiation (mostly in the context of negotiation over remuneration) suggests the context is critical, with women being less likely to negotiate on their own behalf than men, but more likely if they need to do so on behalf of others (Bowles *et al.* 2005). It seems the preparedness to negotiate also depends on the gender of the person being negotiated with, women being more prepared to negotiate with women (Bowles *et al.* 2007).

Bertrand (2011) examines the limited set of studies that try to assess whether these psychological perspectives on gender are useful in explaining differences in the labour market outcomes of the genders and concludes that the research is largely in its infancy and has not yet begun to deliver much consistency in results. Studies of the role of the Big Five personality traits typically find that they differ between men and women, as do the associated returns between men and women (Mueller and Plug 2006, Cobb-Clark and Tan 2011). Both genders receive a return to being open to experience, while men receive a return for being antagonistic (not agreeable), while women receive a return to being conscientious. Cobb-Clark and Tan (2011) also studied the relationship between broadly-defined occupation choices and the Big Five personality traits, finding their effects on occupation differed between the genders.

It is not clear where these gender differences in psychological factors come from, though evidence clearly points to socialisation and environmental factors playing an important role. For example, Booth and Nolen (2012a) find that gender differences in risk attitudes depend on whether the girls have attended a single or co-educational school, with girls from single sex schools exhibiting risk preferences no different from boys. In a later study, Booth *et al*. (2014) found that the girls from single sex study groups in a co-educational environment took riskier gambles than those in co-educational study groups. In another study, Booth and Nolen (2012b) found girls from single sex schools were as willing to compete as much as boys. Studies of matrilineal societies (where inheritance and clan membership follow female lineage) find women are as likely to compete as are men in patriarchal societies (Gneezy *et al.* 2008), and phenomena such as spatial abilities, viewed as essential for engineering courses and which show large gender disparities in patriarchal societies (Voyer *et al.* 1995), disappear in matrilineal societies (Hoffman *et al.* 2011). Other studies focus on the role of teachers and their gender relative to that of the student. Assignment to same-gender teachers has been found to improve student performance for both boys and girls and to improve teachers' perceptions of students (Hoffman and Oreopoulos 2009, Carrell *et al*. 2010).

Another factor that may contribute to gaps in outcomes between males and females are prevailing social norms about what it is appropriate for men and women to do (Akerlof and Kranton 2000). An individual's identity may reflect their sense of belonging to specific social groupings, with associated views about what behaviours belonging to those groups entail. If identity enters an individual's utility function directly, departures from behavioural norms for the individual's group will involve decreased utility, and promote conformist behaviour. Gender stereotypes, held by more than just members of the self-identifying group, may well shape the norms adopted by members of the group. Hence, observed gender differences can reflect social learning rather than anything inherently different between the genders. Some empirical studies in this vein use school settings, focussing on differences in behaviour between girls who attend single-sex schools from those in co-educational schools (Maccoby 1990, 1998, Lee and Marks 1990, Booth and Nolen 2012b). Unfortunately, tests that distinguish the role of gender identity from other explanations of the acceptance of gender stereotypes are very difficult to formulate.

The existence of differences in these psychological factors clearly contributes to "explaining" some part of observed differences in job choices and remuneration by gender. However, their existence prompts two further questions: where did these differences come from and under what circumstances can they be influenced? Since it is clear that social conditioning plays at least some part (Booth *et al*. 2014, for example), these are not necessarily "fixed" factors. OECD (2015) provides a review of the policies implemented in countries in pursuit of gender equality in education.

3. Data and Methodology

3.1. PIRLS & TIMSS Data

This study uses Australian data from two international studies: the Trends in International Mathematics and Science Study (TIMSS) for 2007 and 2011 and the Progress in International Reading Literacy Study (PIRLS) 2011 survey (see Thomson *et al*. 2008, Thomson *et al*. 2012a, 2012b).

PIRLS involves an assessment of the reading achievement of students in Year 4 in 2011. TIMSS involves an assessment of the mathematical and scientific achievement of students in Years 4 and 8. For the 2011 survey, a stratified random sample of 280 primary schools (42 in Victoria) participated in the data collection for both the TIMSS and PIRLS 2011 Year 4 studies. The sample of secondary schools for Year 8 TIMSS in 2011 was of 275 schools (43 in Victoria). The samples were stratified by state, school sector and rurality. The national sample sizes of the data used here are set out in Table 1.

Some 6126 and 6146 students undertook the PIRLS and TIMSS Year 4 tests respectively (around 764 in Victoria) in 2011. Two classrooms per school were sampled, along with all of the indigenous students found in Year 4 in the sampled schools. All sampled students for TIMSS at Year 4 also were asked to take the PIRLS reading tests. More students undertook the Year 8 TIMSS tests – 7556 (958 in Victoria). There were no overlapping schools between the Years 4 and 8 samples. From the 2007 TIMSS survey, only the Year 4 data are used. Some 229 schools (35 in Victoria) and 4106 students (559 in Victoria) were surveyed across Australia.

A key purpose of the PIRLS and TIMSS studies is the production of internationally comparable student achievement scales in mathematics, science and reading (for Year 4), that are also comparable over time. These scales are all calculated to have a mean of 500 and standard deviation of 100 across students from all countries participating in the PIRLS and TIMSS studies for both Year levels.

The scores for males and females for the various achievement tests appear in Table 2. All of the values are at least 500, which indicate that the tests generally show Australian students to be performing above average. For achievement in mathematics and science, males tend to score slightly higher than females, though few of the differences in the TIMSS studies are statistically significant. So, boys and girls in Australia tend to perform about the same, on average, in mathematics and science. However, girls in Year 4 in the 2011 PIRLS study had substantially higher average reading achievement than boys (536 compared with 519), a familiar result from other studies such as PISA.

In addition to the achievement tests, students completed questionnaires about their family backgrounds and attitudes towards reading (in PIRLS), mathematics and science (in TIMSS). The various scales derived from these attitudinal questions are described in the next sub-section.[2]

3.2. Attitudinal scales available in TIMSS/PIRLS

Four scales that reflect different aspects of student attitudes toward learning are available for some or all of the domains for both Year 4 and Year 8 students. These scales reflect whether students *like*, *value*, have *confidence in learning* and are *engaged* in lessons in the relevant domain. All scales are based on student responses to a set of questions or prompts to which they are asked to *strongly disagree*, *disagree*, *agree* or *strongly agree*. The specific prompts for each of the scales used in 2011 are set out in Appendix A.[3] The pattern of scales available across the two studies in the two years is set out in Table 3.

The Students *like* learning mathematics (or science) scale investigates how students feel about mathematics (or science) and is based on five prompts, including "I enjoy learning <subject>", among others. Student's *confidence* in learning mathematics (or science) scale aims to capture aspects of students' past experience in learning the subjects, reflecting its perceived difficulty as well as the individual student's own learning ability and experiences in and out of the classroom.

The Students *value* learning mathematics (or science) scale is designed to get at how attracted to mathematics (or science) and more motivated to learn students are if they perceive achievement in the subject as advantageous to their future education and the world of work. It is asked only of Year 8 students, so only data from 2011 are used in this study.

---

[2] In 2012, just over 13,000 Year 6 students undertook science tests and reported their attitudes towards science as part of the Australian National Assessment Program (NAP) (ACARA 2013). There was no difference in average achievement between boys and girls, and unfortunately the published student survey information did not distinguish responses by gender, so they are not used here.

[3] The number of prompts used for the *Like* and *Confidence* scales increased between 2007 and 2011, but this does not affect the results since enough items were common to both years.

The Students *engaged* in mathematics (or science) lessons scale summarises students' responses to five questions about their levels of engagement in the mathematics classroom, including "I am interested in what my teacher says". The relevant prompts were asked only in 2011.

These scales have mean values around 10 and standard deviations of approximately 2. The numbers in the tables of results discussed in the next section reflect this scale. In the figures discussed in the next section, the attitudes variables have been rescaled to reflect the value as a percentage of the maximum and minimum values of individual for the scale.[4]

3.3. Methodology

Suppose that student attitudes towards a mathematics or science subject for any individual are related to their achievement in the following linear way:

$$(1)\ \boldsymbol{y_{ij}} = \boldsymbol{\alpha_{gj}} + \boldsymbol{A_{ij}\gamma} \quad + \boldsymbol{\mu_i} + \boldsymbol{\epsilon_{ij}}$$

where $\boldsymbol{y_{ij}}$ is the measured attitude for student i in subject j, the A_{ij} is the measure of their achievement in that subject, α_{gj} a subject-specific intercept for the gender, ϵ_{ij} is a random error and $\boldsymbol{\mu_i}$ is a term that is common for the student about how they answer any question about how much they like or value a subject (they might "hate" or "love" everything). Note that $\boldsymbol{\gamma}$ is a parameter to be estimated, and given the way it is written, it is common across subjects and the same for boys and girls. This assumption can be tested in estimation. Given this structure, any differences between genders can by captured by re-writing equation (1) as

$$(2)\ \boldsymbol{y_{ij}} = \boldsymbol{\alpha_{fj}} + \boldsymbol{gender} * (\boldsymbol{\alpha_{mj}} - \boldsymbol{\alpha_{fj}}) + \boldsymbol{A_{ij}\gamma} \quad + \boldsymbol{\mu_i} + \boldsymbol{\epsilon_{ij}}$$

or,

$$(3)\ \boldsymbol{y_{ij}} = \boldsymbol{\pi_j} + \boldsymbol{gender} * \boldsymbol{\tau_j} + \boldsymbol{A_{ij}\gamma} \quad + \boldsymbol{\mu_i} + \boldsymbol{\epsilon_{ij}}$$

where the parameter $\boldsymbol{\tau_j}$ is the "true" difference in attitudes between boys and girls in subject *j*. The problem with simple estimation of the differences in attitudes from the mean values of the attitudes for boys and girls is that equation (3) makes clear that such a comparison actually estimates (when achievement does not differ on average between the genders)

---

[4] That is, *new scale value* =[(old *scale* value – *scale*(minimum))/ (*scale*(maximum) – *scale*(minimum))]

$$(4)\ \bar{\boldsymbol{y}}^{m}_{.j} - \bar{\boldsymbol{y}}^{f}_{.j} = \boldsymbol{\tau_j} + \bar{\boldsymbol{\mu}}^{m} - \bar{\boldsymbol{\mu}}^{f}$$

which consists of the true difference in attitudes, plus any average difference in the way the genders tend to answer questions about the specific attitude, regardless of what subject they are describing. If girls are always more positive than boys in describing themselves as liking school work, then this could translate into them appearing to like a particular subject more than boys, yet the subject may be not really one of their favourites. Regression estimates will also provide an estimate of the gender difference like that of equation (4), so running a regression, rather than comparing the mean attitude values of the genders does not help much. One way of dealing with this is to examine the difference in the attitudes between two subjects. In this case, if $\Delta\boldsymbol{y_i} = \boldsymbol{y_{ij}} - \boldsymbol{y_{ik}}$ equation (1) becomes

$$(5)\ \Delta\boldsymbol{y_i} = (\Delta\boldsymbol{\alpha_m} - \Delta\boldsymbol{\alpha_f}) + \Delta\boldsymbol{A_i\gamma} + \Delta\boldsymbol{\epsilon_i}$$

and

$$(6)\ \overline{\Delta\boldsymbol{y}}^{m}_{.} - \overline{\Delta\boldsymbol{y}}^{f}_{.} \cong (\Delta\boldsymbol{\alpha_m} - \Delta\boldsymbol{\alpha_f})$$

if achievement levels do not differ too much between the genders, since $\boldsymbol{\gamma}$ is common and $\boldsymbol{E}(\Delta\boldsymbol{\epsilon})=\mathbf{0}$ **.** If achievement does differ, equation (5) can be estimated as

$$(7)\ \Delta\boldsymbol{y_i} = \boldsymbol{\theta} + \boldsymbol{gender} * \boldsymbol{\delta} + \Delta\boldsymbol{A_i\gamma} + \Delta\boldsymbol{\epsilon_i}$$

where $\boldsymbol{\delta}$ estimates any additional preference boys have towards (or against) subject *j* over subject *k* compared to the attitudes girls have towards subject *j* and subject *k*.

There is a sense in which both the estimator from equation (4), $\boldsymbol{\tau_j} + \bar{\boldsymbol{\mu}}^{m} - \bar{\boldsymbol{\mu}}^{f}$, or its regression counterpart from equation (3) and the estimator $\boldsymbol{\delta}$ from equation (7) both tell us something important about attitudes towards school subjects. The first tells us whether boys like (or whatever the attitude is) a subject more than girls. The second tells us, conditional on how much boys and girls tend to like subjects in general, whether boys like subject *j* over subject *k* more than girls do. Since both may be informative, but for different purposes, estimates of both parameters for mathematics and science for a variety of attitudes, are provided in this paper.

Despite the equations, the methodology followed in this paper to assess differences in boys and girls attitudes towards mathematics and science involves a set of relatively simple comparisons. These include comparisons of the mean values for the various attitudes towards maths and science scales for boys in Years 4 and 8 with those of girls in the same grade (so, based on equation (4)). Second, we look at a series of simple graphs of how average attitudes towards maths and science for boys and girls vary as achievement varies, which tells us something about the parameter $\boldsymbol{\gamma}$. By looking at how different the attitudes of the two genders are at the top, middle and bottom of the achievement distribution we can see how much the estimator from equation (4) varies. We also undertake a series of simple regressions of attitudes on gender, achievement and family background variables, though do not make too much of these regression results. Mostly the regression estimates just confirm the results from the comparison of means, because the achievement and family background variables do not differ much on average between boys and girls in these data. We also estimate a series of equations like equation (7), of the difference in attitudes towards mathematics and science for individuals regressed on their gender and the difference in their achievement levels in the two subjects. The parameters of those equations tell us whether boys have more favourable attitudes towards mathematics than science than do girls.

All of the regression estimates presented in this paper are descriptive. Since causation is likely to run both ways between attitudes and achievement, there must be doubts about any specific set of regression estimates of the relationship between achievement and attitudes. There are no completely compelling ways of addressing this issue with the available data. But estimation of that relationship is not the point of the paper. Rather including achievement in the regression equations simply serves the purpose of ensuring that the comparisons of attitudes are made between individuals with similar levels of achievement.

A second issue for the analysis is that the data allow identification of when differences in attitudes towards maths and science begin to diverge for boys and girls, but do not really allow much analysis of why they do. However, it is possible to rule out some potential explanations. These include the role of school sector, so we can ask: are the trends different between public and private schools, are they different in single sex schools, does SES play any role, what about differences in the language background or birthplace of parents, the educational attainment aspirations of children or the gender of current mathematics or science teacher. These phenomena are examined via simple comparisons on the mean values of the attitude scales and through estimation of the regression equations for differing sub-groups of the population. The regression results are discussed in more detail below.

4. Results

4.1. Key differences in attitudes between boys and girls

Differences in attitudes towards mathematics and science between boys and girls appear to develop between Years 4 and 8. While some differences in attitudes towards mathematics exist at Year 4, these become larger by Year 8 and differences in attitudes towards science become apparent.

Table 5 shows the mean values for the various attitude scales for mathematics and science in Years 4 and 8 in Australia for 2011, as well as mathematics and science achievement scores. In general, the average values for the attitudinal scales for boys are about the same for Year 4 students as those in Year 8. But the values for girls fall, so differences "move" in favour of boys. Boys in Year 8 are more likely to *like*, be *confident* about, be *engaged* in class and *value* mathematics and science than girls than is the case among Year 4 students. In Year 4, boys are more *confident* and *like* mathematics more than girls, but are less *engaged* in both mathematics and science lessons than are girls.

Note that these differences in attitudes exist despite there being no difference in actual achievement in mathematics and science between boys and girls in Year 4, while boys perform better in science in Year 8 than do girls, but not mathematics (Table 2). In reading in Year 4, where girls do have higher levels of achievement than do boys, boys *like* it less, are less *confident* and less *engaged* in class than girls (see Table 6).

The Year 4 2011 patterns are very similar to the available attitudinal scales from the Year 4 2007 TIMSS collection – boys are more confident about their ability in mathematics but do not like it more, while they appear to like science a little less than girls. These figures are also shown in Table 6. Note that the 2007 Year 4 cohort is the same cohort of students as sampled in the Year 8 2011 survey. Hence, while we cannot strictly speak about gaps in attitudes between boys and girls "opening up" between Year 4 and Year 8 from the 2011 data, it is clear we can use this shorthand, since the Year 4 attitudes are qualitatively similar in 2007 to those of 2011.[5]

---

[5] Note that the 2007 attitudinal scales are placed on a different scale from the 2011, but this has no implications for the analysis.

Similar patterns to those at the national level for mathematics in Table 5 are evident in mathematics for Victoria in Table 7, but less so for science, where the average values of the scales are lower in Year 8 than in Year 4 by about the same amount. In this case, the girls' science scales match those for Australia, but the average values for the boys are lower in Victoria than elsewhere.

That there is a gap between boys and girls in secondary school in their attitudes towards mathematics and science is evident in other data. Data from the Programme for International Student Assessment (PISA) study show a gap in such attitudes between 15 year old boys and girls in Australia. PISA is different from TIMSS in that it collects attitudes towards domains on a rolling three year cycle – reading one cycle, then mathematics, then science. This allows innovation in the conceptual bases of the attitudes asked about and the resulting scales, so the scales are not strictly comparable across reading, mathematics and science.

Aspects of the comparability of the mathematics and science scales in TIMSS with those of the PISA collections from 2006, 2009 and 2012 are presented in Table 4, which represent the science (see Thomson & De Bortoli 2008), reading (see Thomson *et al*. 2010) and mathematics (see Thomson *et al*. 2013) stages of the PISA domain cycle. While there is no directly comparable scale to the TIMSS Engagement scale, there are PISA scales that overlap with the other TIMSS scales. The average values for boys and girls for these scales are shown in Table 8. Like the TIMSS scales, the PISA scales also tend to show a gap between the reports of boys and those of girls in mathematics and science. The *self-concept*, *intrinsic motivation* and *instrumental motivation* in PISA all show that fifteen year-old males answered the various prompts more positively in 2012 than did females. Note that the PISA reading attitude scales suggest that girls have more positive attitudes towards reading than do boys, consistent with the Year 4 PIRLS results in Table 6.

These patterns of an increasing gap between the attitudes of males and females towards mathematics and science opening up between Years 4 and 8 are also evident in Figures 1 through 5. Figure 1 shows the average value for Australia for the *confidence* scales in reading, mathematics and science at each level of achievement in reading, mathematics and science for boys and girls in Year 4, while Figure 2 contains the same relationships in mathematics and science for boys and girls in Year 8. In Year 4, there is little difference in the lines for boys and girls in reading and science, and a small gap in *confidence* in favour of boys in mathematics. In Year 8, the gap in mathematics in favour of boys was wider and there was also a gap in *confidence* in science in favour of boys across the entire achievement distribution. Similar gaps between boys and girls are apparent in how much they *like* mathematics and science and possibly how much they *value* it. Girls seem about as *engaged* in mathematics and science as boys in Year 8. In general, *engagement* in either mathematics or science increases less with achievement than do the other attitude variables (the lines in Figure 3 are typically flatter than the other Figures).

4.2. Possible explanations

What factors might be responsible for the gap between the attitudes of males and females opening up between Years 4 and 8? The data allow us to look at the potential role of school sector, single sex schools, whether SES plays any role, language background and the birthplace of parents, the educational attainment aspirations of children and the gender of current mathematics or science teacher. In short, we find that none of these factors appear to contribute much to the results, suggesting that the widening gap phenomenon occurs across the entire school system and occurs between boys and girls, regardless of their background characteristics.

In the series of tables that report these various results, only the differences between boys and girls in Year 8 for the various attitude variables are shown. This allows us to reduce the number and detail of the tables, and avoids presentation of results for Year 4 where there are few differences between boys and girls in terms of attitudes.

The first three columns of Table 9 show the differences in attitudes towards mathematics and science between boys and girls in Year 8 in Government, Catholic and Independent schools. The standard errors of many of the estimated means blow out substantially, given the smaller sample sizes in private schools. And while some of the gaps in the attitudes towards mathematics and science between boys and girls seem larger in private schools, very few of these differences in the gaps between school sectors are statistically significant.

The differences in attitudes towards mathematics and science between boys and girls in Year 8 in co-educational and single-sex schools are shown in the fourth and fifth columns of Table 9. The sample sizes in single sex schools are very small and the results do not point to consistent results between school types towards mathematics and science. The gaps in attitudes between boys and girls are larger empirically in mathematics in co-educational schools, while in science they are larger in magnitude between the boys and girls who attend single sex schools. None of these apparent differences in the gaps between school types are statistically significant, however. While not shown, it is apparent that the average values for these attitudinal variables are higher in the single sex schools than in co-educational schools, with the values relatively larger in the single sex schools for girls in mathematics and boys in science.

The differences in attitudes towards mathematics and science between boys and girls in Year 8 across the achievement distribution, in this case captured by quartiles of achievement, are shown in Table 10. While the gaps in attitudes between boys and girls in both mathematics and science appear to increase with achievement (this is consistent with most of the figures, where the gaps between the lines tend to increase), few of the differences in the gaps are significantly different from one another. Hence, it appears that where significant gaps exist in the attitudes of boys and girls towards mathematics and science, these mostly hold across the entire distribution of achievement.

The differences in attitudes towards mathematics and science between boys and girls in Year 8 across the social background distribution, captured by SES quartiles, are shown in Table 11. The SES measure is based on the TIMSS variable that captures access to home educational resources, and is a combination of parental education, books in the home and home study supports. The gaps in attitudes between boys and girls in both mathematics and science appear to increase with SES, as do the gaps in achievement. However, few of the differences in the gaps are significantly different from one another. Hence, it appears that where significant gaps exist in the attitudes of boys and girls towards mathematics and science (and their achievement), these are similar across the entire social background distribution.

The differences in attitudes towards mathematics and science between boys and girls in Year 8 across their educational attainment aspirations are shown in Table 12. There are no obvious patterns of differences in the gaps across anticipated educational attainment levels. The gaps in attitudes towards mathematics and science are largest numerically between boys and girls planning to attend university, as are the achievement differences, but few of the differences are significantly different from one another.

The differences in attitudes towards mathematics and science between boys and girls in Year 8 across their birthplace and language backgrounds are shown in Table 13. The groups distinguished are those who live in English only speaking households compared with households where other languages are spoken at home and the student was either born in Australia or not. In general, the gaps in attitudes between boys and girls are largest in households where only English is spoken, though the differences from other household types are not significant.

The differences in attitudes towards mathematics and science between boys and girls in Year 8 by the gender of their teacher are shown in Table 14. Students with male mathematics teachers exhibit the same gender-based differences in attitudes as students with female mathematics teachers. Boys say they *like* mathematics more, are more *confident* about it and say they *value* it more than girls, regardless of the gender of their teacher. Likewise, the gender of teachers in science does not appear to induce any significant differences in the gender-based gap in attitudes (or achievement) in science. Boys say they *like* science more, are more *confident* about it and say they are more *engaged* by the lessons than girls, regardless of the gender of their teacher.

4.3. Regression analysis

Simple regression analysis confirms that the differences in attitudes towards mathematics and science between boys and girls in Year 8 are widespread. Summaries of the regression results showing the implied differences in attitudes are presented for mathematics in Table 15 and science in Table 16. Results for three specifications are presented in the tables. The results in the first row show the gender gap in attitudes when the relevant achievement measure is the only other variable included in the regression equation. The second row show the results when a set of covariates are added to the explanatory variables. These variables are just those listed in the bottom panel of the table: future educational attainment aspirations, SES quartile, school sector, whether the school is a single-sex school, the language background/birthplace of the student, and whether the student has a teacher from the same gender, the same set of variables used in the tables just presented. The third row shows the average gender gap in attitudes when each of these variables is interacted with the gender variable, allowing it to vary across values of the covariates. The lower panel of the tables show just how the estimated gender gaps in attitudes do vary across the SES distribution or across attainment aspirations, for example. The four columns show the gender gap results for the *like*, *confidence*, *engagement* and *value* scales, respectively. Blank cells indicate that the estimated gender gap was not significantly different from zero.

The regression results largely confirm the material presented to date. The apparent, but small, gender gaps in *engagement* in both mathematics and science disappear when covariates are added to the regression equations. But for the other attitude variables, the gender gaps persist when covariates are added. While the gender gaps vary somewhat across the covariate categories, they are a widespread phenomenon: they occur across the SES distribution; they occur in government, Catholic and Independent schools; they exist across all levels of educational aspiration; they are apparent regardless of the background/birthplace of the student; and they are not influenced by gender matches between students and their teachers. In general, the magnitude of the effect size is somewhere 10-20% of a standard deviation of the dependent variable, so the gender differences captured generally represent "smallish" effects. The one qualification to this general picture is that the gender gaps seem typically larger in co-educational schools than exists between boys who attend boys-only school and girls who attend girls-only schools.

Another aspect of the regression analysis undertaken that is worth noting is that the relationships between the attitudes and achievement is linear. Hence, differences in attitudes between boys and girls towards mathematics and science, where they exist, appear to be just a parallel shift in the lines, and do not involve different relationships between attitudes and achievement;

4.4. Within student effects

One issue with the approach adopted so far is that individuals will have underlying levels of "confidence" or propensities to indicate they "like" something that will influence their responses to both their attitudes towards mathematics and science. It seems important to eliminate these individual elements of the relationships estimated so far to see what aggregate gender effects are left over after these effects have been taken into account.

One way to do this is to regress the difference in the attitudes of individuals between mathematics and science on the differences in their estimated achievement in the two domains, along with a gender indicator to see if there is any difference between boys and girls in how being relatively better in one of the subjects translates into differences in attitudes towards the subjects. This is just equation (7), as specified earlier.

It should be noted that the individual questions used to elicit responses from individuals about their attitudes towards mathematics and science are identical except for the exchange of "mathematics" and "science", so differences in the responses should reflect real differences in attitudes to the subjects, not differences that alternative wording might cause.

The first thing to note about this analysis is that being relatively better in one subject compared to the other is associated with more positive attitudes towards the subject in which the individual performs best. This is shown in Figure 6, where being better in all of the lines showing the association between relative subject attitudes are positively associated with relative achievement. The relationship is most positive for the *like* and *confidence* scales, and less pronounced for the *engaged* and *value* scales.

The gap between the lines for males and females shows whether the relationship between relative subject achievement and relative attitudes towards subjects is different for males compared to females. From Figure 6, there are small positive gaps in favour of males between the lines for the *confidence* and the *value* scales, the hint of a negative gap for the *engaged* scale and very little difference on the *like* scale.

To take the *confidence* scale result as an example, this means that between a boy and girl who, to exactly the same extent are better in mathematics than science, this will be typically be associated with a higher level of confidence in mathematics for the boy than the girl. This result does not arise because boys may be more confident than girls in general, but is an effect specific to the relationship between achievement and confidence. Note also, that among students who are worse in mathematics than science, boys will typically also be more confident than girls. The same holds in terms of how much boys say they *value* a subject - for most of the range with a large number of observations, where boys are better in one domain than another, this translates into them saying they *value* that domain more.

This general picture is confirmed in the first row of Table 17. It contains the estimated gender gap of the regression of the differences in attitudes reported by individuals regressed on the differences in their achievement and a gender indicator, for each of the four attitudes. The results confirm small positive gender gaps for males in the *confident* and *value* scales, and a small negative gap in favour of girls for the *engaged* scale. The gender variable was not significant for the *like* scale.

The remaining rows of Table 17 report the gender gaps across the four attitudes where the fixed effects estimation takes place over populations that match the descriptors in the left hand column. For example, the first set of estimates is made only over the population who intend to leave school before they complete Year 12. For the most part, the estimated gender disparities for groups of individuals with specific characteristics or are in similar types of schools accord with the aggregate estimate. For example, all of the *value* estimates that are significant are of a very similar magnitude to the aggregate estimate. Where the cells are blank, this means that any estimated difference was not significantly different between the genders. This might arise if the estimated gap was small, or where the number of observations was small such that the resulting standard error of the estimate was large.

In a handful of cases, it is of some note that the cell is blank where the other cells of the column are consistently positive or not blank. The patterns for the attitudes for single sex schools and Catholic schools seem to depart from those for other schools. There is a substantial degree of overlap between these two types of school in the data – around 60 per cent of the students in a single sex school were in a Catholic school. In the case of Catholic schools, a result that departs from those in the other cells of the column has meaning, as the number of observations in Catholic schools is large enough that the standard errors are small. Hence, the negative number in the *like* column means that girls in Catholic schools indicate that they *like* mathematics relatively more than boys do. For the other attitudes, the blank cells mean that boys and girls are no different from boys in their other attitudes towards mathematics and science. Similarly, the negative numbers in the *like* and *confident* columns mean that girls in single-sex schools indicate that they *like* or are *confident* about mathematics more than boys in single-sex schools.

5. Conclusions

This paper documents the relationships between student attitudes towards mathematics and science and their actual achievement for boys and girls in Years 4 and 8. While there are some differences in these attitudes between boys and girls in Year 4, they widen substantially towards boys having more positive attitudes than girls by Year 8. The results are specific to mathematics and science – girls have more positive attitudes towards reading than boys in Years 4 and at age 15, so the deterioration in attitudes towards mathematics and science does not appear to be part of some more general trend.

The Year 4 difference between boys and girls is in terms of boys being more confident about their ability in mathematics. This is likely something about the tendency towards over-confidence in boys, rather than specifically about mathematics. Boys marginally say they like mathematics more in Year 4, but appear to be less engaged in their mathematics classes than girls. By Year 8, however, boys indicate they do like mathematics and science more, are more confident about their ability and say they value both more than girls. Mostly the emerging differences in responses between the genders appear to come from the boys answers being unchanged between Years 4 and 8, while those of the girls are lower in Year 8 than the answers to comparable questions in Year 4. That is, between Years 4 and 8, it is the reported attitudes of girls that deteriorate towards mathematics and science rather than that of boys' attitudes improving in favour of mathematics and science. This deterioration in attitudes has nothing to do with any change in relative achievement between boys and girls, since achievement is accounted for in the analysis.

Little of the difference in attitudes towards mathematics and science between boys and girls in Year 8 seems to be explained by the characteristics and circumstances of boys and girls. Across a set of school and individual characteristics, differences in attitudes towards mathematics and science exist between boys and girls in Year 8. Where individual responses to the attitude questions across mathematics and science are used, which removes the effects of family background and personality factors that lead people to answer questions in particular ways, boys tend to favour mathematics in terms of their confidence and how much they value the subject, while girls attitudes to science are relatively stronger. The exception to this statement is that girls in single sex schools have stronger attitudes towards mathematics than science compared to boys, unlike girls in co-educational schools. Differences in psychological factors between girls in single sex schools and other girls, or findings of no differences between girls in single sex schools and boys have been found in previous studies, which suggest that there may be factors around the environment in which girls are placed that influence their reported attitudes. This provides cause for hope, though identification of exactly what might work to actually change large number of girls' attitudes towards mathematics and science remains a challenge. OECD (2015) identify a number of directions in which policies can be pursued: promoting self-confidence among girls, encouraging teachers to deal with their implicit and explicit gender biases, and getting students to look ahead to post-secondary study and the labour market as they plan their school careers.

References

Akerlof, GA & Kranton, RE (2000), 'Economics and identity', *Quarterly Journal of Economics,* 115, 715–753.

Australian Curriculum and Assessment Reporting Authority (ACARA), (2013), *National Assessment Program – Science Literacy Year 6 Report 2012*, Sydney.

Bertrand, M (2011) 'New Perspectives on Gender', in Ashenfelter, O & Card D. (eds), Handbook of *Labor Economics*, Vol IVb, Elsevier, Amsterdam.

Bonin, H, Dohmen, T, Falk, A, Huffman, D & Sunde, U (2007) 'Cross sectional earnings risk and occupational sorting: the role of risk attitudes', *Labour Economics* 14 (6), 926–937.

Booth, AL & Nolen, P (2012a), 'Gender differences in risk behaviour: does nurture matter?' *Economic Journal*, 122, Issue 558, pages F56–F78

Booth, AL & Nolen, P (2012b), 'Choosing to compete: How different are girls and boys?', *Journal of Economic Behaviour and Organisation*, 81, 542 -555.

Booth, A, Cardona-Sosa, L & Nolen, P (2014), 'Gender Differences in Risk Aversion: Do Single-Sex Environments Affect their Development', *Journal of Economic Behavior and Organization*, 99, 126 – 154

Bowles, HR, Babcock, L & McGinn, KL, (2005), 'Constraints and triggers: situational mechanics of gender in negotiation', *Journal of Personality and Social Psychology* 89, 951–965.

Bowles, HR, Babcock, L & Lai, L, (2007), 'Social incentives for sex differences in the propensity to initiate negotiation: sometimes it does hurt to ask', *Organizational Behavior and Human Decision Processes* 103, 84–103.

Carrell, SE, Page, ME &West, JE, (2010), Sex and science: how professor gender perpetuates the gender gap. *Quarterly Journal of Economics,* 125 (3), 1101-1144

Cobb-Clark, DA & Tan, M (2011), 'Noncognitive skills, occupational attainment, and relative wages', *Labour Economics*, 18, 1-13.

Croson, R & Gneezy, U, (2009), 'Gender differences in preferences', *Journal of Economic Literature*, 47 (2), 1–27.

Eckel, CC & Grossman, PJ, (2008a), 'Sex and risk: experimental evidence', in Plott, C & Smith, V (Eds.), *Handbook of Experimental Economics Results*, vol. 1. Elsevier, New York.

Eckel, CC & Grossman, PJ, (2008b) ‘Differences in the economic decisions of men and women: experimental evidence’, in Plott, C & Smith, V (Eds.), *Handbook of Experimental Economics Results*, vol. 1. Elsevier, New York.

Gneezy, U, Niederle, M & Rustichini, A, (2003), ‘Performance in competitive environments: gender differences’, *Quarterly Journal of Economics,* 118, 1049–1074.

Gneezy, U., Leonard, K. L. and List, J. A. (2009) “Gender differences in competition: Evidence from a matrilineal and a patriarchal society”, Econometrica, 77, pp. 1637-1664.

Goldin, C. and Katz, L. F. (2012) Th*e most egalitarian of all professions: Pharmacy and the evolution of a family-friendly occupation*, Working Paper 18410, National Bureau of Economic Research.

Healy, J., Mavromaras, K. and Zhu, R. (2013) *The STEM Labour Market in Australia. Contributing consultant report to ‘STEM: Country Comparisons’ project*. National Institute of Labour Studies, Flinders University, on behalf of ACOLA. Australian Office for the Chief Scientist: Canberra. Available online,

http://www.acola.org.au/PDF/SAF02Consultants/Consultant%20Report%20-%20Australian%20Labour%20Market.pdf

Hedges, L. V. and Nowell, A. (1995), “Sex differences in mental test scores, variability, and numbers of high-scoring individuals”, *Science*, 269, 41, copyright - Copyright American Association for the Advancement of Science Jul 7, 1995; Last updated - 2010-06-08; CODEN - SCIEAS.

Herbert, J & Stipek, D (2005), ‘The emergence of gender differences in children’s perceptions of their academic competence’, *Applied Developmental Psychology*, 26, 276–295

Hill, C., Corbett, C. and St. Rose, A. (2010) *Why So Few? Women in Science, Technology, Engineering and Mathematics.* American Association of University Women: Washington, D.C.

Hoffman, M, Gneezy, U & List, J (2011), ‘Nurture affects gender differences in spatial abilities’, *Proceedings of the National Academy of Science*, 108(36), pp. 14786- 4788

Hoffmann, F & Oreopoulos, P, (2009), ‘A professor like me: the influence of instructor gender on college achievement’, *Journal of Human Resources* 44 (2), 479–494.

Holt, CA & Laury, SK, (2002), ‘Risk aversion and incentive effects’, *American Economic Review* 92 (5), 1644–1655.

Justman, M and Mendez, SJ (2016), *Gendered selection of STEM Subjects for Matriculation*, Melbourne Institute Working Paper 10/16, Melbourne.

Lee, VE & Marks, HM (1990), 'Sustained effects of the single-sex secondary school experience on attitudes, behaviors and value on college', *Journal of Educational Psychology* 81, 578–592.

Levin, IP, Snyder, MA & Chapman, DP, (1988), 'The interaction of experiential and situational factors and gender in a simulated risky decision-making task' *Journal of Psychology* 122, 173–181.

Lundeberg, MA, Fox, PW, Punccohar, J, (1994), 'Highly confident but wrong: gender differences and similarities in confidence judgments', *Journal of Educational Psychology*, 86 (1), 114–121.

Maccoby, EE (1990), "Gender and relationships: a developmental account', *American Psychologist* 45 (4), 513–520.

Maccoby, EE (1998), *The Two Sexes: Growing up Apart, Coming Together*, Harvard University Press, Cambridge, Massachusetts.

Marginson, S.M., Tytler, R., Freeman, B. and Roberts, K. (2013) *STEM: Country comparisons* Report for PMSEIC and the Office for the Chief Scientist. ACOLA, Melbourne. Available online,

http://www.acola.org.au/PDF/SAF02Consultants/SAF02_STEM_%20FINAL.pdf

Mueller, G & Plug, E (2006), 'Estimating the effect of personality on male and female earnings', *Industrial and Labor Relations Review,* 60 (1), 3–22.

Niederle, M & Vesterlund, L (2007), 'Do women shy away from competition? Do men compete too much?' *Quarterly Journal of Economics* 122 (3), 1067–1101.

OECD (2015), *The ABC of Gender Equality in Education: Aptitude, Behaviour, Confidence*, PISA, OECD Publishing.
Available online http://dx.doi.org/10.1787/9789264229945-en

Pope, D. G. and Sydnor, J. R. (2010) "Geographic variation in the gender differences in test scores", *The Journal of Economic Perspectives*, 24, pp. 95_108.

Roberts, K (2014), Engaging more women and girls in mathematics and STEM fields: The international evidence, Report prepared for the Australian Mathematical Sciences Institute, Available online, http://amsi.org.au/publications/gender-report-20104/

Salvi Del Pero & Bytchkova (2013), *A bird's eye view of gender differences in education in OECD countries*, OECD Social, Employment and Migration Working Papers, No. 149, OECD Publishing,

Available online, http://dx.doi.org/10.1787/5k40k706tmtb-en.

Sikora, J & Saha, L (2011), *Lost talent? The occupational ambitions and attainments of young Australians.* LSAY Research Innovation and Expansion Fund, National Centre for Vocational Education Research, Adelaide.

Thomson, S and De Bortoli, L (2008), *Exploring scientific literacy: how Australia measures up: the PISA 2006 survey of students' scientific, reading and mathematical literacy skills*, Australian Council for Educational Research, Camberwell.

Thomson, S, De Bortoli, L, & Buckley, S (2013), *PISA 2012- How Australia Measures Up - The PISA 2009 assessment of students' reading, mathematical and scientific literacy,* Australian Council for Educational Research, Camberwell.

Thomson, S, De Bortoli, L, Nicholas, M, Hillman, K & Buckley, S (2010), *Challenges for Australian Education – Results from PISA 2009 - The PISA 2009 assessment of students' reading, mathematical and scientific literacy,* Australian Council for Educational Research, Camberwell.

Thomson S, Hillman, Hillman K& Wernert, N (2012a), *Monitoring Australian Year 8 student achievement internationally: TIMSS 2011*, Australian Council for Educational Research, Camberwell.

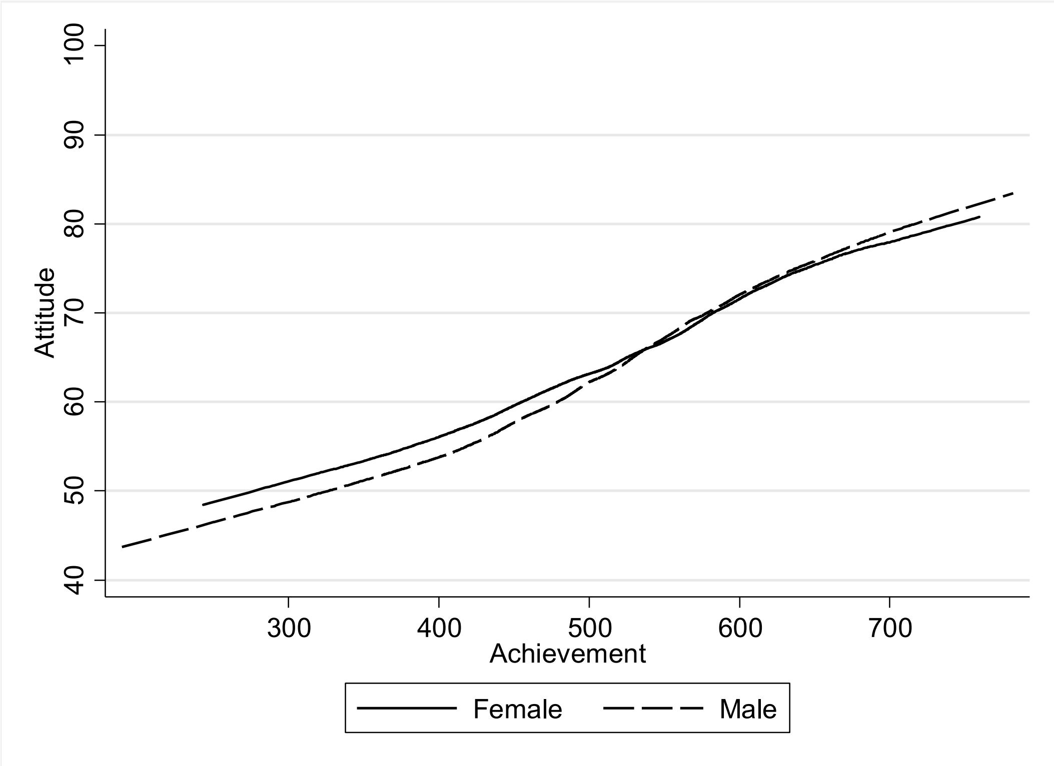
Thomson S, Hillman, K, Wernert, N, Schmid M, Buckley, S & Munene, A (2012b) *Monitoring Australian Year 4 student achievement internationally: TIMSS and PIRLS 2011*, Australian Council for Educational Research, Camberwell.

Thomson, S, Wernert, N, Underwood, C, & Nicholas, M (2008) *TIMSS 07: Taking a closer look at mathematics and science in Australia,* Australian Council for Educational Research, Camberwell.

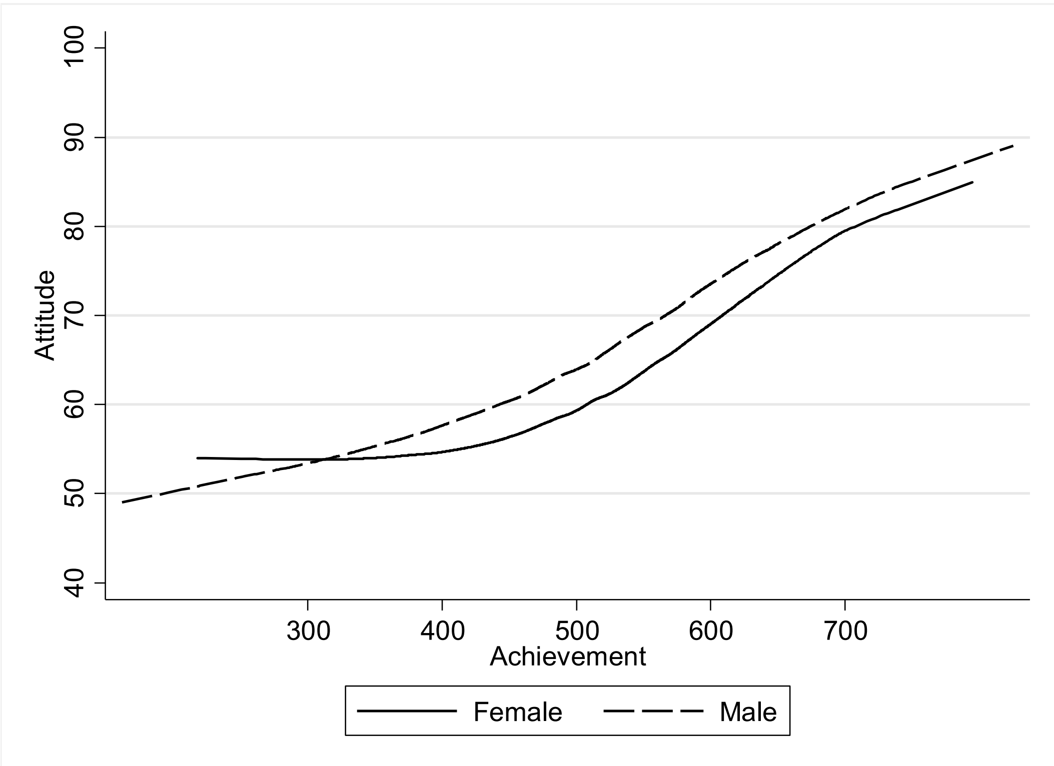
Voyer, D, Voyer, S, Bryden, MP, (1995), 'Magnitude of sex differences in spatial abilities: a meta-analysis and consideration of critical variables', *Psychological Bulletin,* 117, 250–270.

Figure 1: Year 4: *Confidence* in reading, mathematics and then science

(a) Reading



(b) Mathematics



(c) Science

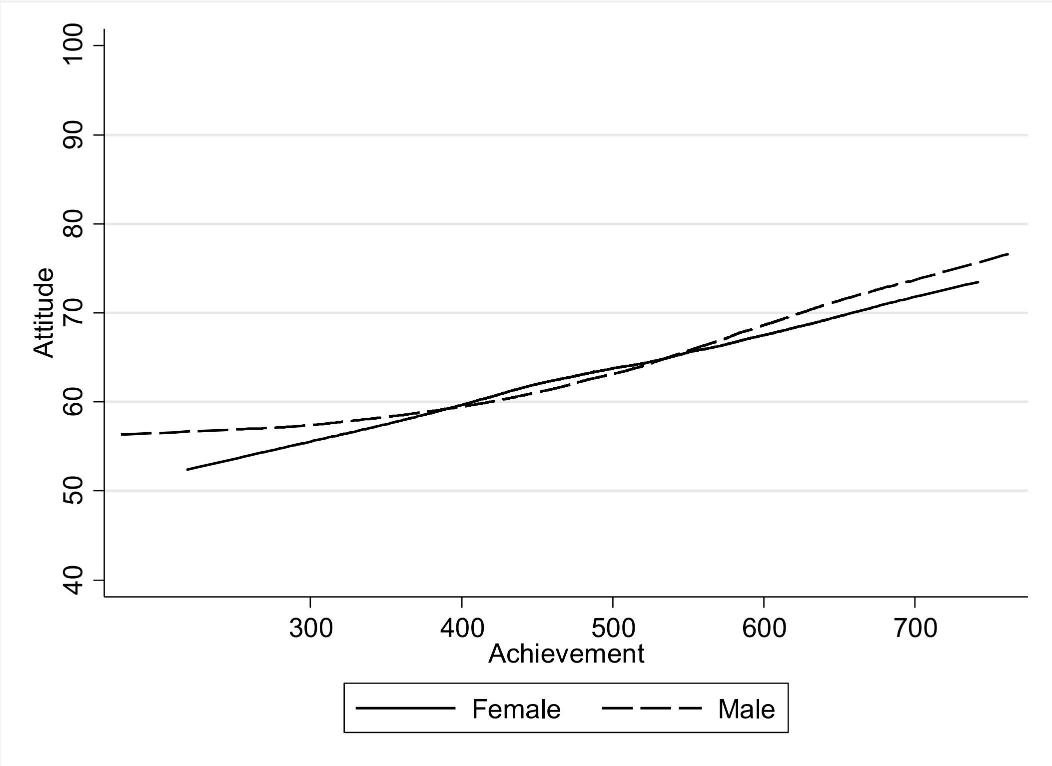
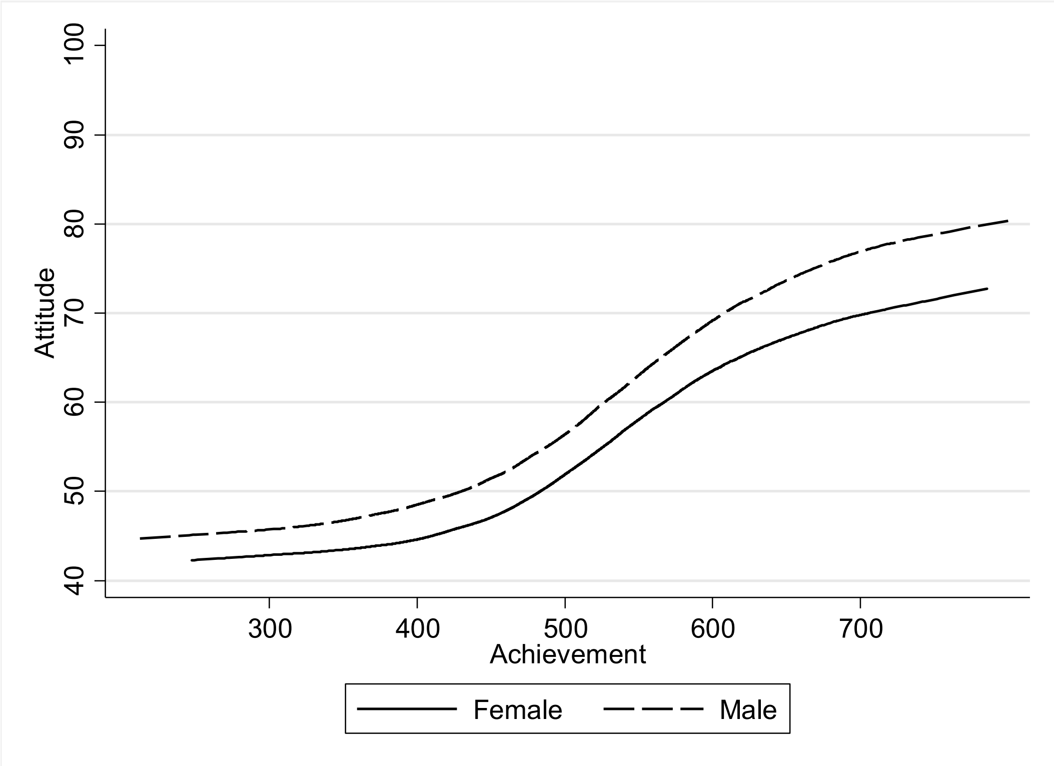

Attitude
100
90
80
70
60
50
40
300
400
500
600
700
Achievement
Female
Male

Figure 2: Year 8 *Confidence*: maths then science

(a) Mathematics



(b) Science

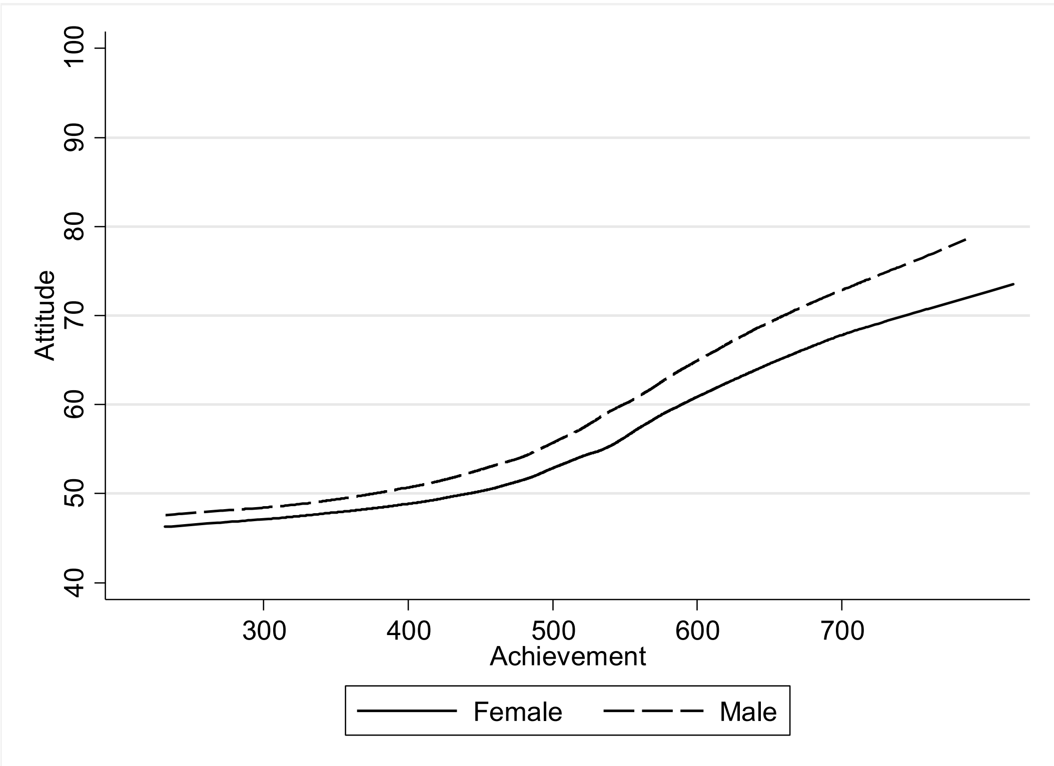
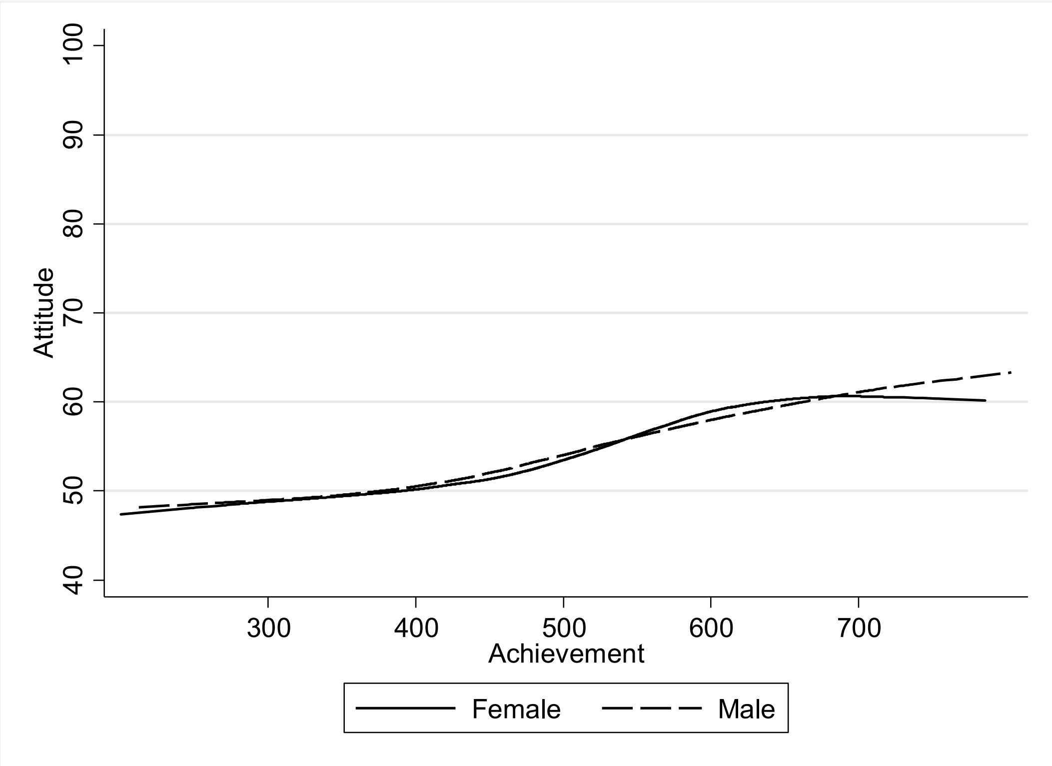


Figure 3: Year 8 *Engaged*: maths then science

(a) Mathematics



(b) Science

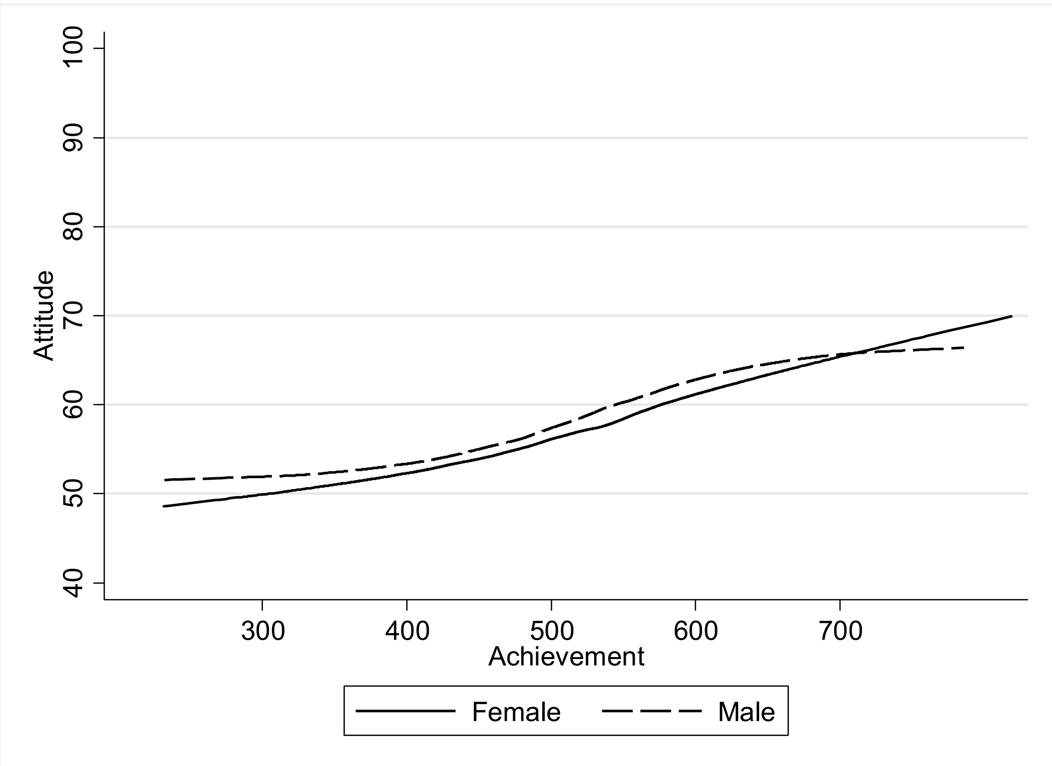
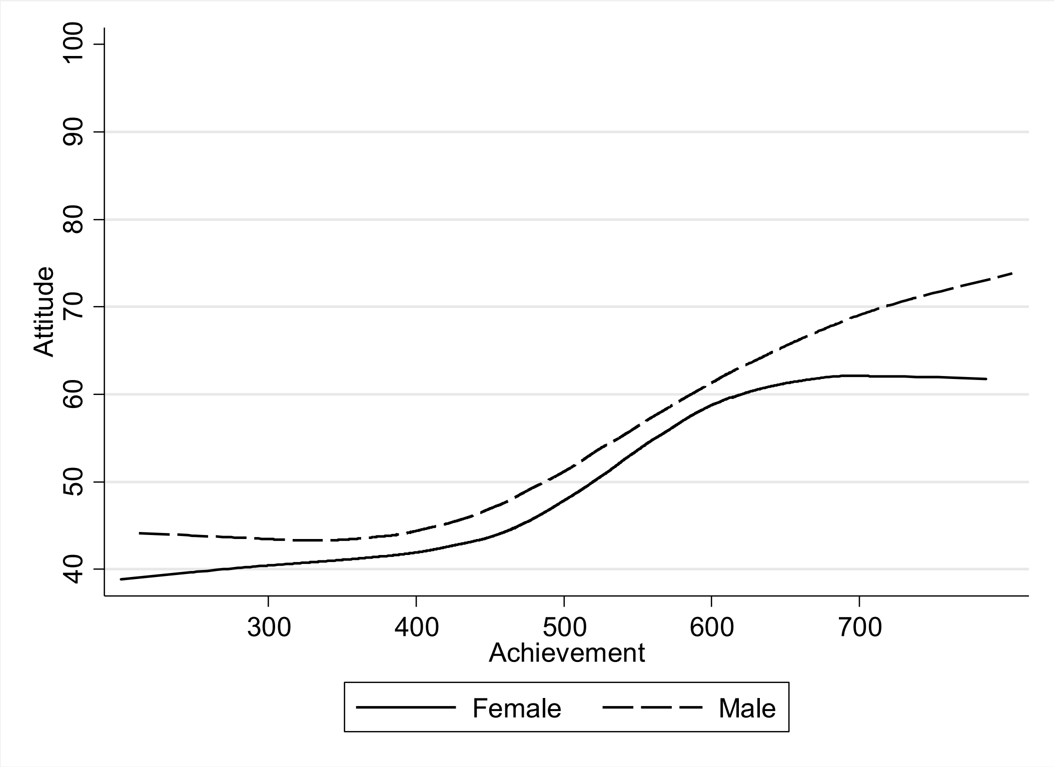


Figure 4: Year 8 *Likes*: maths then science

(a) Mathematics



(b) Science

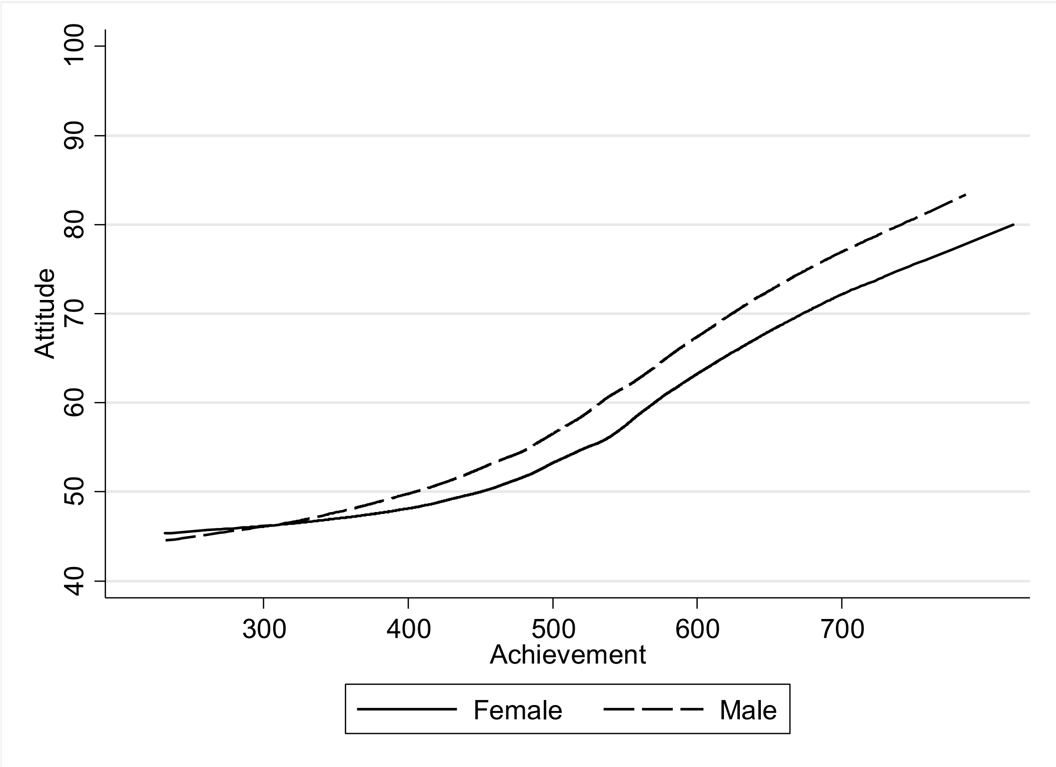
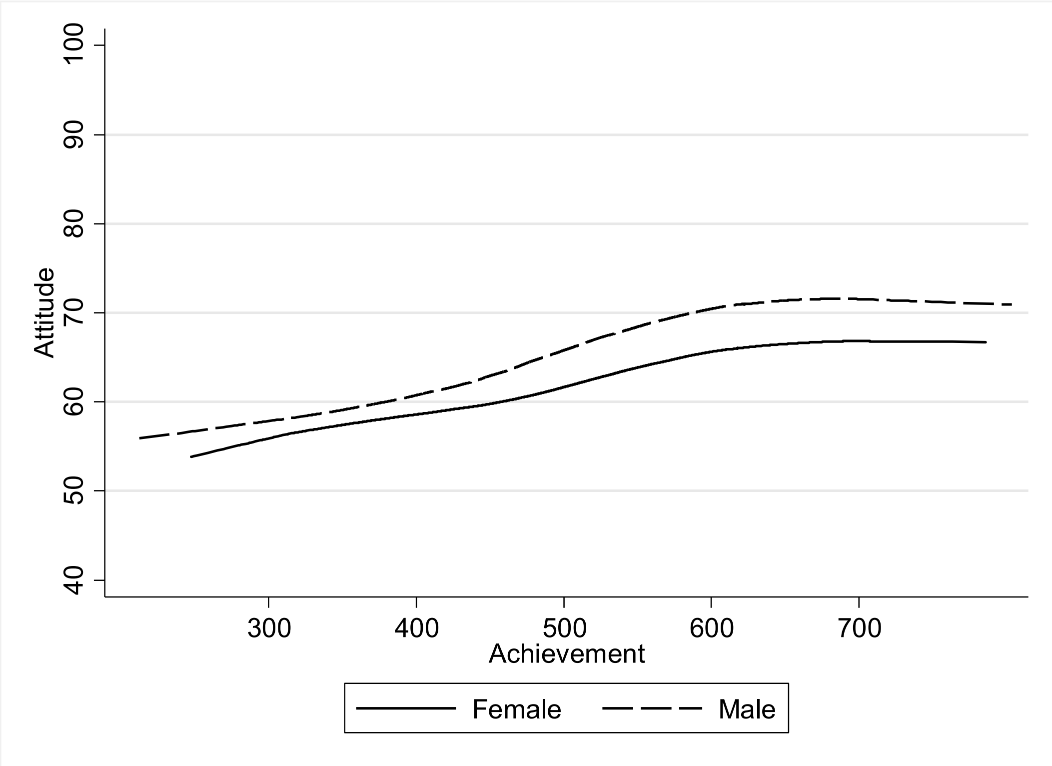


Figure 5: Year 8 *Values*: maths then science

(a) Mathematics



(b) Science

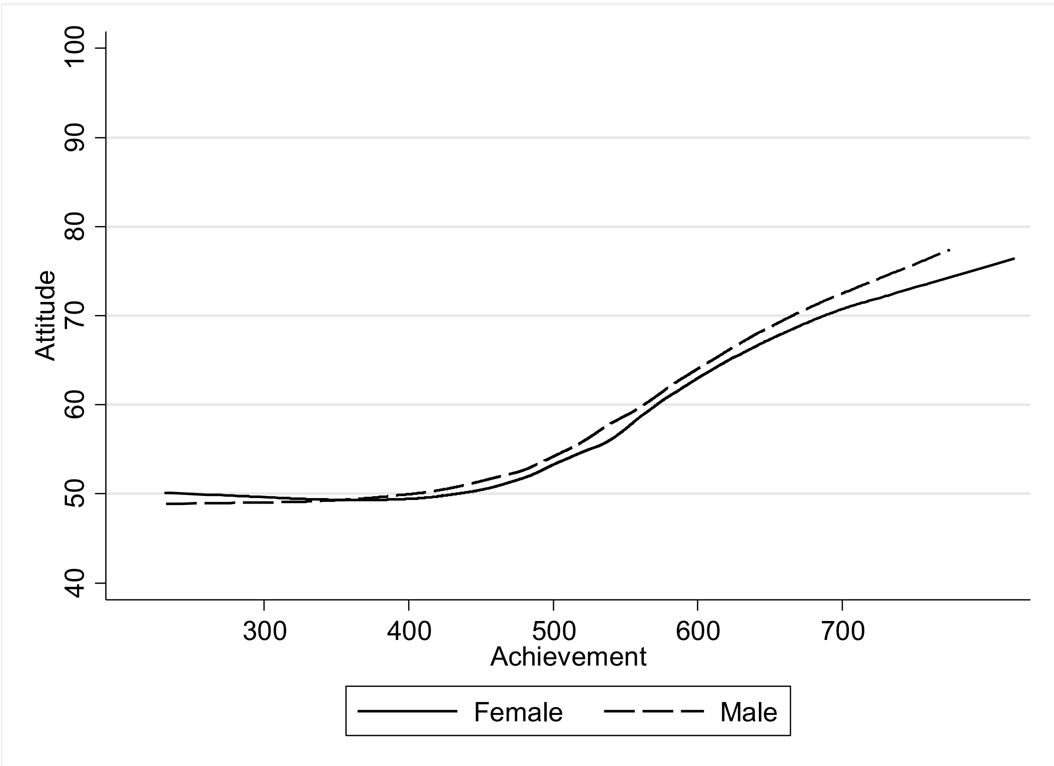
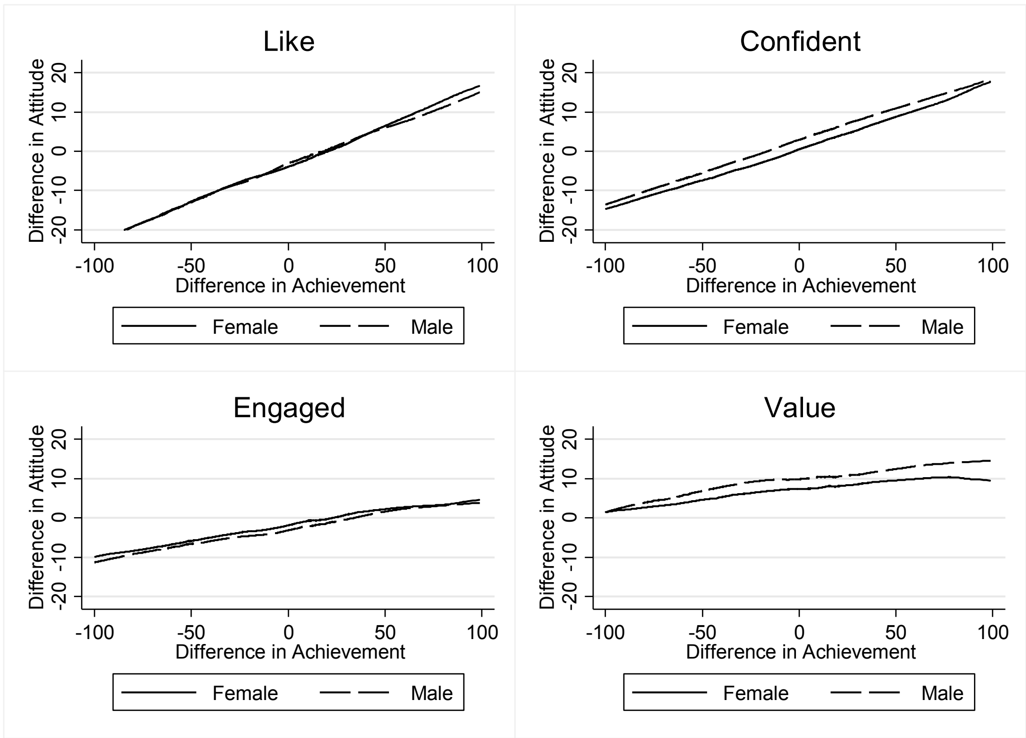


Figure 6: Gender differences in how being better at mathematics than science translates into differences in attitudes towards mathematics and science

(a) Year 8



(b) Year 4

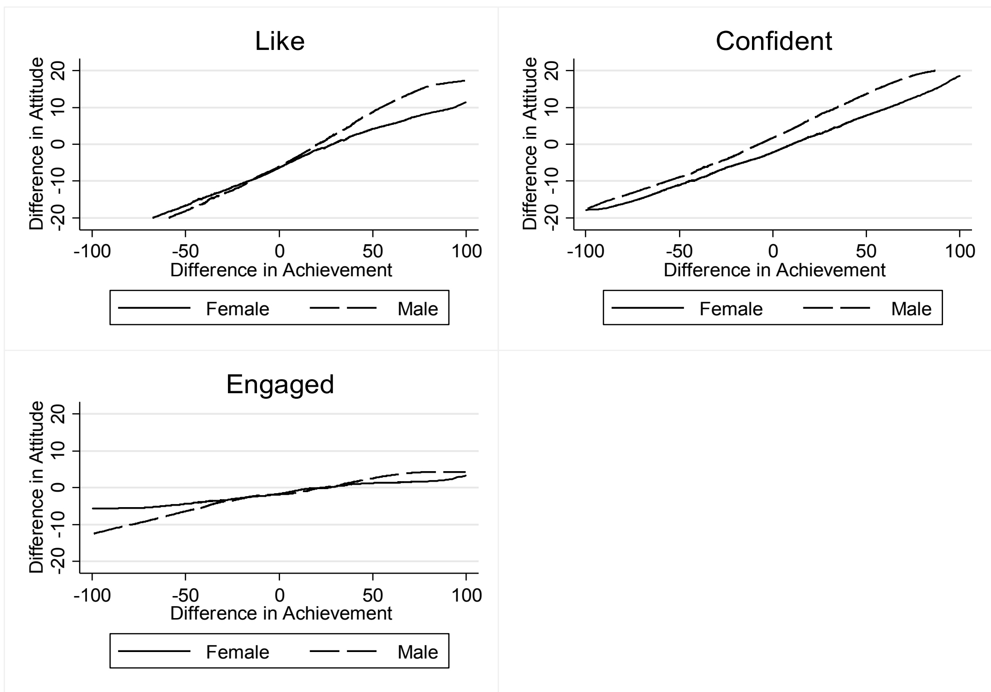


Table 1: Sample sizes, TIMSS 2007 and PIRLS/TIMSS 2011

	Schools		Students	
	Year 4	Year 8	Year 4	Year 8
2007				
TIMSS	229		4108	
2011				
PIRLS	280		6126	
TIMSS	280	275	6146	7556

Table 2: PIRLS/TIMSS Achievement scores by gender, various years

	Boys	Girls	Difference	Year
Year 4				
Mathematical Achievement	519	513	6	2007
Scientific Achievement	530	525	5	2007
Mathematical Achievement	519	513	6	2011
Scientific Achievement	516	516	0	2011
Reading Achievement	519	536	-17***	2011
Year 8				
Mathematical Achievement	509	500	9	2011
Scientific Achievement	527	511	16***	2011

'***' means the boys' value is significantly different from the girls' value at the 1 per cent level (two tail test).

Table 3: Student attitude scales in PIRLS/TIMSS, various levels and years

	Year 4 2007	Year 4 2011	Year 8 2011
Students *Confident* in <Subject>	Mathematics, Science	Reading, Mathematics, Science	Mathematics, Science
Students *Like* Learning <Subject>	Mathematics, Science	Reading, Mathematics, Science	Mathematics, Science
Students *Engaged* in <Subject> lessons		Reading, Mathematics, Science	Mathematics, Science
Students *Value* <Subject>			Mathematics, Science

Where <Subject> is alternately Mathematics, Science or Reading.

Table 4: Student attitude scales in PIRLS/TIMSS compared with PISA

PIRLS/TIMSS scale	**Approximately comparable PISA scale**
Students *Confident* in <Subject>	Index of mathematics *self-concept*
Students *Like* Learning <Subject>	Index of *intrinsic motivation* to learn mathematics/*Enjoyment* of science
Students *Engaged* in <Subject> lessons	No related PISA scale
Students *Value* <Subject>	Index of *instrumental motivation* to learn <Subject>

Where <Subject> is alternately Mathematics, Science or Reading.

Table 5: Base case – means values of achievement and attitudinal scales for boys and girls by grade, Australia 2011

	Year 4 2011			Year 8 2011		
	Boys	Girls	Diff.	Boys	Girls	Diff.
Students Like Learning	9.8	9.7	0.16**	9.5	9.2	0.28***
Mathematics	(0.07)	(0.07)	(0.08)	(0.08)	(0.07)	(0.08)
Student Confidence With	10.4	9.9	0.53***	10.5	9.9	0.65***
Mathematics	(0.05)	(0.07)	(0.07)	(0.10)	(0.06)	(0.10)
Students Engaged In	9.7	10.1	-0.35***	9.4	9.3	0.06
Mathematics Lessons	(0.07)	(0.07)	(0.07)	(0.06)	(0.08)	(0.08)
Students Value Learning				10.2	9.8	0.40***
Mathematics				(0.07)	(0.05)	(0.08)
1st Plausible Value	524.2	515.5	8.69**	510.4	502.2	8.25
Mathematics	(3.42)	(3.15)	(3.96)	(7.28)	(4.70)	(6.89)
Students Like Learning	10.0	10.0	0.01	9.6	9.1	0.45***
Science	(0.07)	(0.06)	(0.09)	(0.10)	(0.08)	(0.10)
Student Confidence With	9.9	9.9	-0.01	10.0	9.5	0.54***
Science	(0.06)	(0.06)	(0.06)	(0.09)	(0.06)	(0.09)
Students Engaged In	9.8	10.1	-0.31***	9.7	9.4	0.24***
Science Lessons	(0.07)	(0.07)	(0.08)	(0.07)	(0.09)	(0.09)
Students Value Learning				9.2	9.0	0.21*
Science				(0.10)	(0.07)	(0.12)
1st Plausible Value	523.3	520.2	3.13	530.8	514.1	16.72***
Science	(3.40)	(2.85)	(3.88)	(6.58)	(4.35)	(5.91)

'***', '**' and '*' mean the boys' value is significantly different from the girls' value at the 1, 5 and 10 per cent level respectively. Numbers in parentheses are standard errors.

Table 6: Mean values of achievement and attitudinal scales for boys and girls in Year 4, Australia 2007 and 2011

	Year 4 2007			Year 4 2011		
	Boys	Girls	Diff.	Boys	Girls	Diff.
Students Like Learning	0.02	0.00	0.02	9.8	9.7	0.16**
Mathematics	(0.03)	(0.04)	(0.04)	(0.07)	(0.07)	(0.08)
Student Confidence With	0.10	-0.09	0.19***	10.4	9.9	0.53***
Mathematics	(0.03)	(0.03)	(0.04)	(0.05)	(0.07)	(0.07)
Students Engaged In				9.7	10.1	-0.35***
Mathematics Lessons				(0.07)	(0.07)	(0.07)
1st Plausible Value	519.2	514.2	4.94*	524.2	515.5	8.69**
Mathematics	(3.45)	(3.88)	(2.64)	(3.42)	(3.15)	(3.96)
Students Like Learning	-0.07	0.00	-0.07**	10.0	10.0	0.01
Science	(0.03)	(0.03)	(0.04)	(0.07)	(0.06)	(0.09)
Student Confidence With	-0.01	-0.02	0.01	9.9	9.9	-0.01
Science	(0.03)	(0.03)	(0.05)	(0.06)	(0.06)	(0.06)
Students Engaged In				9.8	10.1	-0.31***
Science Lessons				(0.07)	(0.07)	(0.08)
1st Plausible Value	529.3	527.4	1.94	523.3	520.2	3.13
Science	(3.21)	(3.49)	(2.53)	(3.40)	(2.85)	(3.88)
Students Like Reading				9.6	10.4	-0.81***
				(0.06)	(0.06)	(0.08)
Student Confidence about				10.0	10.2	-0.24***
Reading				(0.06)	(0.05)	(0.07)
Students Engaged In				9.2	9.9	-0.71***
Reading Lessons				(0.06)	(0.07)	(0.08)
1st Plausible Value				523.8	540.1	-16.26***
Reading				(2.79)	(2.70)	(3.28)

'***', '**' and '*' mean the boys' value is significantly different from the girls' value at the 1, 5 and 10 per cent level respectively. Numbers in parentheses are standard errors.

Table 7: Mean values of achievement and attitudinal scales for boys and girls by grade, Victoria 2011

	Year 4 2011			Year 8 2011		
	Boys	Girls	Diff.	Boys	Girls	Diff.
Students Like Learning	9.9	9.9	-0.03	9.6	9.3	0.30**
Mathematics	(0.14)	(0.18)	(0.18)	(0.15)	(0.11)	(0.14)
Student Confidence With	10.5	10.1	0.43***	10.7	9.9	0.79***
Mathematics	(0.14)	(0.14)	(0.16)	(0.14)	(0.12)	(0.14)
Students Engaged In	9.9	10.3	-0.32**	9.5	9.4	0.01
Mathematics Lessons	(0.16)	(0.16)	(0.13)	(0.17)	(0.15)	(0.16)
Students Value Learning				10.2	9.9	0.31**
Mathematics				(0.10)	(0.10)	(0.13)
1st Plausible Value	535.9	532.7	3.20	508.5	500.6	7.85
Mathematics	(5.35)	(7.29)	(7.76)	(9.60)	(7.37)	(7.47)
Students Like Learning	10.4	10.2	0.21	9.4	9.2	0.21
Science	(0.10)	(0.13)	(0.18)	(0.20)	(0.18)	(0.15)
Student Confidence With	10.1	9.9	0.22	9.7	9.5	0.20
Science	(0.10)	(0.10)	(0.13)	(0.18)	(0.14)	(0.15)
Students Engaged In	10.1	10.3	-0.22	9.5	9.4	0.06
Science Lessons	(0.12)	(0.15)	(0.17)	(0.22)	(0.20)	(0.19)
Students Value Learning				8.8	8.9	-0.11
Science				(0.18)	(0.13)	(0.18)
1st Plausible Value	534.7	530.4	4.32	522.5	507.7	14.80**
Science	(4.86)	(6.59)	(6.79)	(8.31)	(7.17)	(6.09)

'***', '**' and '*' mean the boys' value is significantly different from the girls' value at the 1, 5 and 10 per cent level respectively. Numbers in parentheses are standard errors.

Table 8: PISA Achievement and attitudinal scales by gender, various years

	Boys	Girls	Difference	Year
Reading Achievement	495	530	-35***	2012
Mathematical Achievement	510	498	12***	2012
Scientific Achievement	519	524	5	2012
Reading				
Enjoyment of Reading Index scores	-0.33	0.31	-0.64***	2009
Percentage of students reading for enjoyment	53.0	73.1	-20.1***	2009
Mathematics				
Index of *intrinsic motivation* to learn mathematics	0.26	-0.06	0.32***	2012
Index of *instrumental motivation* to learn mathematics	0.39	0.09	0.30***	2012
Index of mathematics *self-concept*	0.25	-0.13	0.38***	2012
Index of *self-efficacy* mathematics	0.27	-0.17	0.44***	2012
Index of *self-responsibility* for failure in mathematics	-0.38	-0.09	0.29***	2012
Index of mathematics *anxiety*	-0.14	0.20	-0.33***	2012
Index of *subjective norms* in mathematics	0.39	0.23	0.15***	2012
Science				
General *value* of science	0.00	-0.11	0.11**	2006
Personal value of science	Males ahead			2006
Self-efficacy in science	0.19	0.04	0.14**	2006
Self-concept in science	0.07	-0.14	0.22**	2006
General *interest* in learning science		No difference		2006
Enjoyment of science	-0.03	-0.12	0.09**	2006
Instrumental motivation in science		No difference		2006
Future-oriented motivation to learn science	-0.03	-0.12	0.09**	2006

'***' and '**' mean the boys' value is significantly different from the girls' value at the 1 and 5 per cent levels respectively. Positive values mean boys have higher average values for the measured attitudes than girls. Note that boys are *less* anxious about mathematics.

Table 9: Differences in attitudes between Year 8 boys and girls in 2011 by sector/school type (positive values mean boys have higher average attitudes than girls)

	Sector			School type	
	Gov	Cath.	Indep.	Co-ed	Single sex
Students Like Learning Mathematics	0.26***	0.32**	0.25	0.36***	0.10
	(0.09)	(0.13)	(0.32)	(0.07)	(0.39)
Student Confidence With Mathematics	0.56***	0.65***	0.94***	0.74***	0.40
	(0.09)	(0.19)	(0.32)	(0.08)	(0.46)
Students Engaged In Mathematics Lessons	-0.02	0.17	0.14	0.12	-0.04
	(0.09)	(0.21)	(0.31)	(0.07)	(0.35)
Students Value Learning Mathematics	0.34***	0.48***	0.47	0.43***	0.31
	(0.08)	(0.12)	(0.30)	(0.07)	(0.28)
1st Plausible Value Mathematics	-4.45	20.58	31.10	7.70**	31.40
	(4.44)	(16.47)	(25.34)	(3.43)	(34.92)
Students Like Learning Science	0.23**	0.80***	0.69**	0.41***	0.75*
	(0.09)	(0.22)	(0.33)	(0.09)	(0.42)
Student Confidence With Science	0.31***	0.90***	0.80***	0.45***	0.97***
	(0.08)	(0.21)	(0.27)	(0.07)	(0.34)
Students Engaged In Science Lessons	0.01	0.49**	0.65***	0.20**	0.45
	(0.11)	(0.22)	(0.24)	(0.09)	(0.31)
Students Value Learning Science	0.02	0.63***	0.30	0.18**	0.45
	(0.10)	(0.24)	(0.33)	(0.09)	(0.42)
1st Plausible Value Science	2.19	29.51**	45.49**	13.86***	46.73*
	(4.23)	(13.17)	(20.22)	(3.20)	(28.10)

‘***’, ‘**’ and ‘*’ mean the boys’ value is significantly different from the girls’ value at the 1, 5 and 10 per cent level respectively. Numbers in parentheses are standard errors.

Table 10: Differences in attitudes between Year 8 boys and girls in 2011 by achievement quartile#

	Year 8 2011			
	1st quart	2nd quart	3rd quart.	4th quart
Students Like Learning	0.10	0.20*	0.29**	0.29**
Mathematics	(0.12)	(0.11)	(0.12)	(0.14)
Student Confidence With	0.51***	0.53***	0.50***	0.66***
Mathematics	(0.12)	(0.12)	(0.14)	(0.14)
Students Engaged In	0.10	0.01	0.02	-0.01
Mathematics Lessons	(0.16)	(0.13)	(0.14)	(0.15)
Students Value Learning	0.28*	0.12	0.52***	0.54***
Mathematics	(0.14)	(0.13)	(0.12)	(0.10)
1st Plausible Value	2.67	-1.29	-1.20	4.89
Mathematics	(2.48)	(1.17)	(1.18)	(8.80)
Students Like Learning	0.28	0.33**	0.43**	0.57***
Science	(0.17)	(0.14)	(0.18)	(0.17)
Student Confidence With	0.33***	0.44***	0.45***	0.74***
Science	(0.11)	(0.14)	(0.14)	(0.17)
Students Engaged In	0.22	0.01	0.17	0.48***
Science Lessons	(0.14)	(0.13)	(0.16)	(0.14)
Students Value Learning	0.04	0.07	0.23	0.29*
Science	(0.19)	(0.15)	(0.15)	(0.16)
1st Plausible Value	8.43**	9.16***	8.96***	16.82**
Science	(3.62)	(3.47)	(2.96)	(7.30)

'***', '**' and '*' mean the boys' value is significantly different from the girls' value at the 1, 5 and 10 per cent level respectively. Numbers in parentheses are standard errors.

positive values mean boys have higher average attitudes than girls

Table 11: Differences in attitudes between Year 8 boys and girls in 2011 by SES quartile#

	Year 8 2011			
	1st quart	2nd quart	3rd quart.	4th quart
Students Like Learning	0.20**	0.30***	0.34**	0.27
Mathematics	(0.09)	(0.10)	(0.16)	(0.21)
Student Confidence With	0.59***	0.64***	0.68***	0.73***
Mathematics	(0.11)	(0.12)	(0.14)	(0.22)
Students Engaged In	0.18	0.13	-0.09	-0.02
Mathematics Lessons	(0.11)	(0.12)	(0.14)	(0.18)
Students Value Learning	0.30**	0.36***	0.48***	0.51***
Mathematics	(0.12)	(0.10)	(0.13)	(0.15)
1st Plausible Value	3.89	8.09	9.05	14.54
Mathematics	(5.59)	(5.09)	(7.38)	(15.22)
Students Like Learning	0.33**	0.53***	0.28	0.62***
Science	(0.13)	(0.12)	(0.20)	(0.21)
Student Confidence With	0.39***	0.45***	0.51***	0.87***
Science	(0.10)	(0.12)	(0.17)	(0.19)
Students Engaged In	0.18	0.26**	0.04	0.49***
Science Lessons	(0.15)	(0.12)	(0.16)	(0.16)
Students Value Learning	0.07	0.20	0.22	0.38*
Science	(0.14)	(0.13)	(0.17)	(0.21)
1st Plausible Value	9.96**	14.63***	19.12***	27.94**
Science	(4.70)	(4.88)	(5.76)	(11.54)

'***', '**' and '*' mean the boys' value is significantly different from the girls' value at the 1, 5 and 10 per cent level respectively. Numbers in parentheses are standard errors.

positive values mean boys have higher average attitudes than girls

Table 12: Differences in attitudes between Year 8 boys and girls in 2011 by Attainment aspirations[#]

	School incomplete	Year 12	Vocational	University
Students Like Learning	0.20	0.31**	0.41***	0.44***
Mathematics	(0.16)	(0.14)	(0.09)	(0.15)
Student Confidence With	0.53***	0.59***	0.78***	0.93***
Mathematics	(0.18)	(0.13)	(0.11)	(0.15)
Students Engaged In	0.03	0.24*	0.11	0.14
Mathematics Lessons	(0.19)	(0.14)	(0.10)	(0.14)
Students Value Learning	0.49***	0.05	0.53***	0.66***
Mathematics	(0.12)	(0.14)	(0.10)	(0.12)
1st Plausible Value	1.02	15.40***	10.11**	22.87*
Mathematics	(11.20)	(5.05)	(4.71)	(11.73)
Students Like Learning	0.54***	0.44**	0.49***	0.72***
Science	(0.16)	(0.18)	(0.11)	(0.17)
Student Confidence With	0.72***	0.54***	0.42***	0.85***
Science	(0.14)	(0.16)	(0.09)	(0.16)
Students Engaged In	0.36**	0.36**	0.24***	0.40***
Science Lessons	(0.16)	(0.18)	(0.09)	(0.14)
Students Value Learning	0.43***	0.13	0.15	0.60***
Science	(0.16)	(0.19)	(0.11)	(0.17)
1st Plausible Value	13.75	21.38***	18.77***	31.86***
Science	(9.35)	(5.63)	(4.78)	(10.23)

'***', '**' and '*' mean the boys' value is significantly different from the girls' value at the 1, 5 and 10 per cent level respectively. Numbers in parentheses are standard errors.

[#] positive values mean boys have higher average attitudes than girls

Table 13: Differences in attitudes between Year 8 boys and girls in 2011 by Language/birthplace#

	English only at home	Born Aust. Other languages	Born O/seas. Other languages
Students Like Learning	0.30***	0.18	0.37
Mathematics	(0.09)	(0.20)	(0.26)
Student Confidence With	0.71***	0.45**	0.44*
Mathematics	(0.11)	(0.21)	(0.25)
Students Engaged In	0.02	-0.01	0.73***
Mathematics Lessons	(0.09)	(0.22)	(0.23)
Students Value Learning	0.37***	0.48***	0.61**
Mathematics	(0.09)	(0.17)	(0.25)
1st Plausible Value	10.67	-5.58	7.77
Mathematics	(6.81)	(11.67)	(13.91)
Students Like Learning	0.50***	0.30	0.28
Science	(0.11)	(0.25)	(0.30)
Student Confidence With	0.57***	0.52**	0.20
Science	(0.09)	(0.25)	(0.29)
Students Engaged In	0.27***	0.13	0.21
Science Lessons	(0.09)	(0.21)	(0.30)
Students Value Learning	0.24**	0.29	-0.08
Science	(0.11)	(0.27)	(0.33)
1st Plausible Value	18.36***	9.74	9.02
Science	(6.09)	(9.34)	(13.41)

'***', '**' and '*' mean the boys' value is significantly different from the girls' value at the 1, 5 and 10 per cent level respectively. Numbers in parentheses are standard errors.

positive values mean boys have higher average attitudes than girls

Table 14: Differences in attitudes between Year 8 boys and girls in 2011 by teacher gender#

	Maths teacher		Science teacher	
	Female	Male	Female	Male
Students Like Learning Mathematics	0.26**	0.35***		
	(0.12)	(0.13)		
Student Confidence With Mathematics	0.65***	0.73***		
	(0.12)	(0.15)		
Students Engaged In Mathematics Lessons	-0.02	0.23		
	(0.11)	(0.17)		
Students Value Learning Mathematics	0.39***	0.45***		
	(0.10)	(0.16)		
1st Plausible Value Mathematics	7.96	1.73		
	(10.59)	(9.46)		
Students Like Learning Science			0.46***	0.56***
			(0.18)	(0.15)
Student Confidence With Science			0.67***	0.59***
			(0.14)	(0.14)
Students Engaged In Science Lessons			0.27*	0.44***
			(0.15)	(0.15)
Students Value Learning Science			0.20	0.26
			(0.18)	(0.19)
1st Plausible Value Science			21.87**	14.16**
			(9.85)	(7.05)

'***', '**' and '*' mean the boys' value is significantly different from the girls' value at the 1, 5 and 10 per cent level respectively. Numbers in parentheses are standard errors.

positive values mean boys have higher average attitudes than girls

Table 15: Average Gender gap in mathematics scales from regression analysis[#]

	Like	Confident	Engaged	Value
Achievement only	2.8***	4.6***		3.7***
Achievement, plus covariates	3.3***	4.8***	0.6*	4.4***
Achievement, covariates & interactions	3.3***	4.7***	0.6*	4.4***
Future education, incomplete school	2.5**	4.6***		3.5***
Future education, Year 12		3.0***		2.3**
Future education, vocational	3.7***	4.8***		4.5***
Future education, university	4.3***	5.7***		6.1***
Government school	3.6***	4.8***		4.3***
Catholic school	3.1**	4.6***	3.4***	4.6***
Independent school	2.4*	4.8***		4.8***
Single sex school		2.0**	-2.4**	2.7**
Co-educational school	4.0***	5.2***	1.1**	4.7***
First SES quartile (lowest)	3.0**	4.4***	1.5**	3.7***
Second SES quartile	4.4***	4.8***		4.3***
Third SES quartile	3.9***	5.2***		5.1***
Top SES quartile		4.6***		4.9***
English only	3.1***	4.7***		4.2***
Born Australia, Other languages	4.1**	4.7***		5.5***
Born overseas, Other languages	4.9**	4.9***	4.2**	5.9***
Teacher different gender	2.5***	4.6***		4.2***
Teacher same gender	4.6***	5.0***	1.1*	4.8***

'***', '**' and '*' mean the boys' value is significantly different from the girls' value at the 1, 5 and 10 per cent level respectively. Blank cells mean the estimate was not significantly different from zero.

[#] positive values mean boys have higher average attitudes than girls

Table 16: Average Gender gap in science scales from regression analysis#

	Like	Confident	Engaged	Value
Achievement only	3.4***	3.2***	1.3**	1.1**
Achievement, plus covariates	4.5***	3.7***	2.1***	2.3***
Achievement, covariates & interactions	4.5***	3.7***	2.1***	2.4***
Future education, incomplete school	5.8***	5.0***	2.9**	3.3**
Future education, Year 12	2.4*	2.8**	3.0**	
Future education, vocational	3.7***	2.8***	1.6**	
Future education, university	5.5***	4.3***	1.7**	4.6***
Government school	3.4***	3.4***	1.7**	2.0**
Catholic school	6.2***	4.7***	2.4**	3.4**
Independent school	5.9***	3.7***	3.2**	2.5*
Single sex school	3.0*	4.7***		
Co-educational school	4.7***	3.5***	2.4***	2.5***
First SES quartile (lowest)	3.3**	2.6***		
Second SES quartile	5.8***	3.8***	2.6***	2.2**
Third SES quartile	3.8**	3.9***	1.8*	3.7**
Top SES quartile	4.5***	4.7***	2.7**	2.7**
English only	4.3***	3.7***	2.0***	2.2***
Born Australia, Other languages	4.3**	4.0***	2.5**	3.9**
Born overseas, Other languages	7.6***	3.6**	4.0**	
Teacher different gender	4.6***	3.8***	1.7**	2.5***
Teacher same gender	4.3***	3.5***	3.0***	2.1**

'***', '**' and '*' mean the boys' value is significantly different from the girls' value at the 1, 5 and 10 per cent level respectively.

Positive values mean boys have higher average attitudes than girls; uses transformed attitude scales. Blank cells mean the estimate was not significantly different from zero.

Table 17: Gender gap with individual fixed effects#

	Like	Confident	Engaged	Value
Achievement only		2.1***	-1.0**	2.3***
Future education, incomplete school			-2.1**	
Future education, Year 12		1.7*		
Future education, vocational				
Future education, university		2.1**	-1.8**	
Government school	1.7**	2.8***	-1.2**	2.5***
Catholic school	-2.5**			
Independent school		2.4**	-2.9**	2.8**
Single sex school	-3.6**	-1.9*		
Co-educational school		2.8***	-0.9*	2.3***
First SES quartile (lowest)		2.8***		2.0**
Second SES quartile		2.0**		2.4**
Third SES quartile		2.7**		
Top SES quartile			-2.6**	2.7**
English only		2.2***	-1.1**	2.4***
Born Australia, Other languages				
Born overseas, Other languages				
Maths teacher different gender, Science same		2.2***	-1.3**	2.2***
Teacher same gender in both		2.2***	-1.3**	2.2***
Maths teacher same gender, Science different				2.6**
Achievement only – Year 4 2011		3.7***		n/a

'***', '**' and '*' mean the boys' value is significantly different from the girls' value at the 1, 5 and 10 per cent level respectively. Blank cells mean the estimate was not significantly different from zero. # positive values mean boys have higher average attitudes than girls; uses transformed attitude scales.

Appendix A: Data description and summary statistics

Table A1: Students *Confident* in <Subject> (SC_) scale

How much do you agree with these statements about <Subject>?				
(slight differences in wording in these items between Years 4 and 8)	Agree a lot	Agree a little	Disagree a little	Disagree a lot
I usually do well in <Subject>				
<Subject> is harder for me than for many of my classmates*				
I am just not good at <Subject>*#				
I learn things quickly in <Subject> #				
I am good at working out difficult <Subject> problems#				
My teacher tells me I am good at <Subject>				
<Subject> is harder for me than any other subject*				
Additional Year 8 items				
<Subject> makes me confused and nervous*				
My teacher thinks I can do well in <Subject> <programs/classes/lessons> with difficult materials				

Where <Subject> is alternately Mathematics, Science or Reading.

For reading in Year 4, these three items are replaced by "Reading is easy for me", "If a book is interesting, I don't care how hard it is to read" and "I have trouble reading stories with difficult words".

* Reverse coded

Table A2: Students *Like* Learning <Subject> (SL_) scale

How much do you agree with these statements about learning <Subject>?				
	Agree a lot	Agree a little	Disagree a little	Disagree a lot
I enjoy learning <Subject>				
I wish I did not have to study <Subject>*				
<Subject> is boring*				
I learn many interesting things in <Subject>				
I like <Subject>				

Where <Subject> is alternately Mathematics or Science. The Year 4 Reading scale includes the first and third items above, plus six other items that reflect enjoyment of reading and how often individuals read outside school.

* Reverse coded

Table A3: Students *Engaged* in <Subject> (EL_) scale

How much do you agree with these statements about your <Subject> lessons?				
	Agree a lot	Agree a little	Disagree a little	Disagree a lot
I know what my teacher expects me to do				
I think of things not related to the lesson*				
My teacher is easy to understand				
I am interested in what my teacher says				
My teacher gives me interesting things to do				

Where <Subject> is alternately Mathematics, Science or Reading.

For Reading in Year 4, the scale also includes "I like what I read in school" and "My teacher gives me interesting things to read".

* Reverse coded

Table A4: Students *Value* <Subject> (SV_) scale (Year 8 mathematics and science only)

How much do you agree with these statements about <Subject>?				
	Agree a lot	Agree a little	Disagree a little	Disagree a lot
I think learning <Subject> will help me in my daily life				
I need <Subject> to learn other school subjects				
I need to do well in <Subject> to get into the university of my choice				
I need to do well in <Subject> to get the job I want				
I would like a job that involves using <Subject>				
It is important to do well in <Subject>				

Where <Subject> is alternately Mathematics, Science or Reading.

* Reverse coded

Appendix B: Data description and summary statistics

Table B1: Variables used in the Year 8 analysis

Variable name	Description	Mean	Std Dev
Mathematical literacy	1st Plausible value in Mathematics - TIMSS variable: *bsmmat01*	504.7	84.1
Scientific literacy	1st Plausible value in Science - TIMSS variable: *bsssci01*	520.9	83.8
Educational aspirations	Based on answer to "How far in your education do you expect to go":		
<Year 12	*bsbg07* =1	0.19	0.39
Year 12	*bsbg07* =2	0.18	0.38
Post-school qual	*bsbg07* =3 or 4	0.30	0.46
Degree	*bsbg07* =5 or 6	0.33	0.47
School sector	Derived from the sample stratum variable *idstrati*		
Government		0.60	0.49
Catholic		0.23	0.42
Independent		0.17	0.38
Single sex school	The gender composition of the school was derived from the school mean of the individual gender variable, *itsex*	0.18	0.39
Co-educational school		0.82	0.39
SES Quartile 1 (Lowest)	SES quartiles are based on the TIMSS Home Educational Resources, which is a combination of parental education, books in the home and home study supports: *bsbgher*	0.25	0.44
SES Quartile 2		0.34	0.47
SES Quartile 3		0.19	0.39
SES Quartile 4 (Highest)		0.22	0.41

(continued)

Table B1: Variables used in the Year 8 analysis (continued)

Variable name	Description	Mean	Std Dev
Mathematical literacy	1st Plausible value in Mathematics - TIMSS variable: *bsmmat01*	504.7	84.1
English only at home	Based on language spoken at home *bsbg03* =1	0.81	0.40
Born Australia, non-English home language	Birthplace= Australia and *bsbg03* ≠1	0.12	0.33
Born overseas, non-English home language	Birthplace≠ Australia and *bsbg03* ≠1	0.07	0.25
Teacher gender	Genders match in science, but not maths	0.15	0.36
Teacher gender	Genders match in maths and science, or do not match in both	0.66	0.47
Teacher gender	Genders match in maths, but not science	0.19	0.39
Science teacher gender diff	*btbg02* ≠ *itsex*	0.64	0.48
Science teacher gender same	Genders match in science, *btbg02* = *itsex*	0.36	0.48
Maths teacher gender diff	*btbg02* ≠ *itsex*	0.60	0.49
Maths teacher gender same	Genders match in maths, *btbg02* = *itsex*	0.40	0.49

Table B2 – Year 8 2011 Attitude scales – descriptive statistics across the entire sample

Variable name	Description	Original[#]		Transformed[&]	
		Mean	Std Dev	Mean	Std Dev
Mathematics scales					
Likes	TIMSS variable: *bsbgslm*	9.3	1.9	50.9	22.7
Confident	TIMSS variable: *bsbgscm*	10.2	2.1	55.5	16.8
Engaged	TIMSS variable: *bsbgseml*	9.3	1.8	54.9	15.9
Value	TIMSS variable: *bsbgsvm*	10.0	1.8	63.5	17.9
Science scales					
Likes	TIMSS variable: *bsbgsls*	9.3	2.1	57.2	24.8
Confident	TIMSS variable: *bsbgscs*	9.8	1.9	56.2	16.4
Engaged	TIMSS variable: *bsbgsesl*	9.5	1.9	58.1	18.6
Value	TIMSS variable: *bsbgsvs*	9.1	2.1	55.3	23.4

Used in Tables 5 – 12.
& Where *Transformed scale value* = [(*old scale value* – scale(minimum))/ (scale(maximum) – scale(minimum))]. The transformed scale is used in the Figures and Tables 13, 14 and 15.

Table B3 – Year 4 2011 Attitude scales and achievement – descriptive statistics across the entire sample

Variable name	Description	Original#		Transformed&	
		Mean	Std Dev	Mean	Std Dev
Mathematics scales					
Likes	TIMSS variable: *asbgslm*	9.7	2.2	67.9	26.8
Confident	TIMSS variable: a*sbgscm*	10.1	2.1	64.4	20.4
Engaged	TIMSS variable: *asbgseml*	9.9	2.0	68.3	19.2
Science scales					
Likes	TIMSS variable: *asbgsls*	10.0	2.1	74.2	24.9
Confident	TIMSS variable: *asbgscs*	9.9	2.0	64.7	19.3
Engaged	TIMSS variable: *asbgsesl*	10.0	2.0	70.2	19.4
Reading scales					
Likes	PIRLS variable: *asbgslr*	9.9	2.1	59.6	16.8
Confident	PIRLS variable: *asbgscr*	10.1	2.0	65.4	16.0
Engaged	PIRLS variable: *asbgserl*	9.6	1.9	61.3	15.3
Mathematical literacy	1st Plausible value in Mathematics: *asmmat01*	504.7	84.1		
Scientific literacy	1st Plausible value in Science: *asssci01*	520.9	83.8		
Reading	1st Plausible value in Reading: *asssci01*	520.9	83.8		

Used in Tables 5 – 12.
& Where *Transformed scale value* = [(*old scale value* – scale(minimum))/ (scale(maximum) – scale(minimum))]. The transformed scale is used in the Figures and Table 15.