Affect and Gender

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Abstract In this chapter the authors present findings from recent research studies, conducted in different contexts, in which gender issues associated with a range of affective variables included in explanatory models for gender differences in mathematics learning outcomes – achievement and participation – were explored. The studies encompass data gathered from various different groups of students (Indigenous, primary, secondary), parents, mathematics teachers, and the general public. What emerges is an international profile of gender-related affective measures, with varying levels of agreement, which highlight the significance of contextual factors in this field of research. The authors explore the implications of their findings on classroom practice, policy, and future research.

Keywords Gender • Indigenous • Stereotyping • Occupational aspirations • Parents • Attributions • Calculators • Computers • International comparisons

Introduction

Mathematics is an enabling discipline for STEM-based [Science, Technology, Engineering and Mathematics-based] studies at university and related careers and, around the world, males continue to dominate these fields (Blickenstaff 2005; United Nations Educational, Scientific and Cultural Organization [UNESCO] 2012). The contemporary relevance and importance of overcoming this gender imbalance internationally was highlighted at the United Nation's 55th Commission on the Status of Women, held in New York in 2011. It was noted that "… quality education and full and equal access and participation in science and technology for women of all ages are imperative for achieving gender equality and the

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empowerment of women, and an economic necessity…" (Commission on the Status of Women 2011, p. 2).

Serious study of affect within the field of mathematics education stemmed from the early work of those focussing on understanding the observed and consistent patterns of gender differences favouring males in mathematics achievement and in participation in challenging mathematics courses and mathematics-related careers. This work began in English-speaking western nations in the mid 1970s (e.g., in the USA: Fennema and Sherman 1977) and has spread around the globe (see Burton 1990; Forgasz et al. 2010).

Early research efforts resulted in a range of factors being identified as contributors to gender differences in mathematics learning outcomes. Various explanatory models for these gender differences began to emerge in the 1980s (e.g., Eccles et al. 1983; Fennema and Peterson 1985). At the time, it was also postulated that biological factors were implicated in males' superior mathematical performance. These explanations, however, lacked scientific evidence. The implied inevitability of change provoked debate and disquiet among many in the research community. More recent international performance comparisons in the Trends in International Mathematics and Science Studies [TIMSS] (see Mullis et al. 2012) continue to challenge biological explanations, as it is now apparent that in some countries females outperform males.

Other than refining and adding to the psycho-social and socio-cultural variables included in the early explanatory models for gender differences in mathematics performance and participation in challenging mathematics subjects, in participation in higher level tertiary studies and in careers involving mathematics, there has been little new theoretical work in the field. Leder (1990) provided an explanatory framework which incorporated the many common elements encompassed within the postulated models. These were described by Leder (1992) as follows:

> …the emphasis on the social environment, the influence of other significant people in that environment, students' reactions to the cultural and more immediate context in which learning takes place, the cultural and personal values placed on that learning and the inclusion of learner-related affective, as well as cognitive, variables. (p. 609)

Among the variables included in Leder's (1990) explanatory framework were the following learner-related affective variables: confidence; sex-role congruity; perceived usefulness of mathematics; and motivational variables including attributional style, learned helplessness, mastery orientation, and fear of success. Previous research into these variables reported by Leder (1992) had identified gender differences favouring males. Compared to females, males had been found to be more confident about their mathematical capabilities, more comfortable with the view of mathematics and related fields as male domains, and to perceive mathematics as useful; they were also more likely to have functional (leading to future success) attributional styles, that is, they were more likely than females to be mastery oriented and less likely than females to be learned helpless or believe that there was a price to pay for being successful in a male domain (fear of success). To this day, these elements remain useful in designing research studies in mathematics education in which gender equity considerations are relevant (Forgasz 2008).

In this chapter we present findings from five contemporary research studies in mathematics education in which gender and affective variables were of interest. Each study had unique dimensions related to the social context and geographic location, and the participants of interest. The affective variables central to each study varied, although there was some overlap. All were directly related to the range of learner-related variables included in Leder's (1990) explanatory framework for gender differences in mathematics learning outcomes.

Study 1. Primary-aged Australian Indigenous students were the focus. Perceptions of their own mathematical achievement and that of others, their beliefs about the relevance of mathematics for the future, and the students' feelings as they learn mathematics were of interest.

Study 2. Comparisons between Israeli and Australian secondary mathematics teachers' beliefs about the gendering of mathematics as a male, female, or neutral domain, and their beliefs about the reasons girls and boys would give for their successes and failures in mathematics were explored. Whether male and female teachers in each country viewed these issues differently was also of interest.

Study 3. Mozambique was the context for this study. Grade 7 boys' and girls' beliefs about and attitudes towards mathematics, including self-perceptions of achievement and the usefulness of mathematics, the gendering of mathematics, and career aspirations. The students' views were also compared with parents' beliefs for their sons and daughters.

Study 4. In Singapore and Australia, advanced calculators (graphics in Singapore, and Computer Algebra Systems [CAS] in Victoria) are mandated in the high stakes examinations at the end of secondary schooling. Comparisons between Singaporean and Victorian (Australia) male and female senior high school students' self-perceptions of self-competence with mathematics and with the advanced calculators, as well as their enjoyment and confidence with the calculators for mathematics learning were examined.

Study 5. In this study, an online survey, using Facebook as the means to recruit participants from around the world, was conducted to gauge the beliefs of the general public about the gender-stereotyping of mathematics and technology capability. The responses of participants from nine countries were compared.

The background, aims, instruments, and results for each study are presented in turn. The chapter ends with a general discussion of the findings from the five studies, overall conclusions, implications, and reflections on the direction for future work in this field.

Study 1: Australian Indigenous Students, Gender, and Attitudes to Mathematics

A new phase in the assessment of student achievement in mathematics began in Australia in 2008 with the introduction of the National Assessment Program – Literacy and Numeracy [NAPLAN]. Each year since then the NAPLAN tests have been administered to students throughout Australia in Years 3, 5, 7, and 9. Although participation in NAPLAN testing is not compulsory, compliance is high. For example, in 2012 approximately 95 % of the Australian Year 3 cohort and 92 % of the Year 9 cohort completed NAPLAN tests. NAPLAN numeracy tests contain both multiple choice and open-ended items. Some student background information is also gathered: age, gender, Indigenous status, language background status (English/non-English), state/Territory, geolocation (metropolitan, provincial, remote, and very remote), parental educational background, and parental occupation. NAPLAN data are reported overall as well as separately by these different categories. However, no affective data are gathered.

The "Make It Count" Project

One disturbing finding that has emerged consistently from the NAPLAN Numeracy tests, as well as from other data sources (e.g., TIMSS and PISA [Programme for International Student Assessment]) is the lower performance of Australian Indigenous students compared with their non- Indigenous counterparts.

Over the years, various interventions have been introduced to improve the mathematics performance of Indigenous students, including the recently concluded national *Make it Count* [MiC] project.[1] Around 40 primary and secondary schools in eight metropolitan and provincial localities participated in all, or some, components of the MIC project. Attention to affect was part of the project. A survey suitable for Year 3–6 students was devised and administered in participating schools. Responses were examined for gender differences. Findings for Indigenous students were of particular interest. Some schools elected not to participate in the survey.

The Survey, Sample, and Selected Findings

The survey comprised some items with closed response formats and some with open-response formats to explore students' attitudes towards and beliefs about mathematics; similar questions were included about reading. Most items were modelled on those used in the TIMSS and PISA tests (see Thomson et al. 2008; de Bortoli and Thomson 2010). Among the survey items, students were shown three mathematics problems (Q1: calculate arrival time given time of departure and length

[1] *Make it Count: Numeracy, mathematics and Indigenous learners* is a national project that seeks to develop an evidence base of practices to improve the learning outcomes of Aboriginal and Torres Strait Islander (that is, Indigenous) students in mathematics. Eight clusters of schools across urban and regional Australia have been provided with various sources of support "to develop responsive mathematics pedagogy that will engage and inspire Aboriginal and Torres Strait Islander students and contribute to improved learning outcomes." For more details see http://makeitcount.aamt.edu.au/

Table 1 Response frequencies to selected items by indigeneity and sex

Item	Response	Indigenous		Non-indigenous		Comments
		Males (%)	Females (%)	Males (%)	Females (%)	
How good were you at mathematics last year?	Above average	67.8	58.5	66.7	68.2	Indigenous females (F) lowest %
How much do you like mathematics this year?	Yes (A little/ very much)	70.0	68.8	71.7	73.3	Little between group variation but Indigenous F lowest %
How much do you like reading?	Yes (A little/ very much)	68.3	83.1	70.3	84.1	All students, higher % of F than M like reading, χ^2_2, = 27.09, $p < .001$
How much does your best friend like mathematics?	Yes (A little/ very much)	71.7	58.5	66.7	67.2	Indigenous F lowest %
Is mathematics important for grown-ups?	Yes	86.0	89.1	86.4	87.7	Little between group variation but Indigenous F highest %
How sure are you that you can do this question Q1?	Sure	82.5	76.2	81.5	80.7	Indigenous F lowest %
How sure are you that you can do Q2?	Sure	87.5	71.4	81.8	85.0	Indigenous F lowest % and significantly lower than non-Indigenous F, χ^2_2, = 7.854, $p < .05$
How sure are you that you can do Q3?	Sure	72.2	67.7	80.3	73.3	Indigenous F lowest %

of trip; Q2: select a 3-dimensional object after rotation; and Q3: add 17 to a list of three numbers). They were asked to indicate how certain they were that they could answer each correctly; they were NOT asked to find the answers to the problems.

Over 1,200 students completed the survey. Of these, 125 (60 male, 65 female) were Indigenous; 1,108 (561 M, 547 F) were non-Indigenous. Responses to a selection of readily codable items are shown in Table 1.

As can be seen in Table 1, a subtle but unmistakable trend emerged. As a group, Indigenous females were more negative about mathematics, but not about reading, and were somewhat less confident about their mathematics proficiency. Additional information was gleaned from responses to particular open ended items. Detailed responses to two of these open-ended items are shown below.

ITEM 1: Circle the words that show how you feel when you do mathematics (students were shown six positive and six negative adjectives)

Of the adjectives circled by Indigenous males and females, 74 % and 63 % respectively were positive. For the non-Indigenous students, responses were virtually identical: of the adjectives circled by males 69 % were positive, compared with 70 % for females. Thus as a group, non-Indigenous females circled fewer positive adjectives than the other groups. For four adjectives there were notable differences in the proportions circled by female and male Indigenous students: '*Worried*' (M = 5 %; F = 17 %); '*Don't understand*' (M = 12 %; F = 28 %), '*Unhappy*' (M = 8 %; F = 18 %); and '*Not worried*' (M = 37 %; F = 22 %). These responses may help in explaining the Indigenous females' lower confidence in the likely correctness of their answers to the three mathematics problems (see Table 1).

ITEM 2: How will you use mathematics as a grown up?

All groups, it can be seen from Table 1, expected to use mathematics as adults. How much credence should be given to this uniformly high response with respect to the long term utility of mathematics? And do Indigenous and non-Indigenous females have the same expectations?

For both Indigenous and non-Indigenous students, using mathematics for shopping or working out the cost of items featured prominently. So did using mathematics at work, although the nature of that work was often not stated. Some roles were specified by the Indigenous group: shop assistant, teacher, dance teacher, and cook. The only roles nominated by the non-Indigenous group were working in a shop – as a sales person or a cashier (several students) and working in the air force (one student). Usage of mathematics in daily in-home activities was mentioned more frequently by the Indigenous females than by the non-Indigenous females, though again few definite activities were mentioned. A notable exception was the entry from one of the Indigenous students who expected to use mathematics "for counting lots of birds when you are sighting things". Given the age of the sample, students in Years 3–6, the lack of specificity with respect to the relevance of mathematics for their long term life goals is probably to be expected. Realistic expectations of adult life are still elusive.

Summary

The sample comprised students in Years 3–6 at schools involved in the MiC project. For this group it was found that the attitudes of Indigenous females towards mathematics and their expectations of success in that subject were generally less functional (less likely to lead to success) than those of Indigenous males and non-Indigenous students. The scope of the MiC project did not allow a direct link to be made between the students' affective responses and their mathematics performance as measured by the NAPLAN tests. Others, however, have pointed to the impact of affective factors on academic performance. For example, writing about the 2011 TIMSS results for Australia, Thomson et al. (2012, p. 159) noted that:

> Developing positive attitudes towards reading, mathematics and science are important goals of the curriculum, particularly in primary school. Within Australia, students who expressed more positive attitudes and reported a higher level of self-confidence in reading, mathematics and science scored higher in the cognitive assessments than those who expressed less positive attitudes.

To what extent the findings of the MiC sample can be generalised beyond the group is debatable. The sample was drawn from schools directly involved in a project aimed at improving the mathematics performance of Indigenous students at metropolitan and provincial schools. How might findings from schools not involved in such a project differ from those presented here? Should we expect the less functional responses of Indigenous females in other school settings to be lessened or exacerbated? The attitudinal survey used was designed to cater for a wide age range of students attending geographically dispersed schools. The findings are sufficiently provocative to warrant a more in-depth investigation with Australian Indigenous students of different ages and in different settings. How representative these findings are with respect to gender and affect for other Indigenous groups around the globe is also worthy of further study.

Study 2: Australian and Israeli Teachers' Gendered Beliefs About Mathematics

Cross-national comparisons of students' mathematics achievements, and the factors contributing to them, provide valuable insights into the complexities associated with finding explanations for observed patterns of gender difference in cognitive and affective measures. Cultural, ethnic, and societal factors have been found to interact with gender in many such explorations (e.g., Barkatsas et al. 2002; Forgasz and Mittelberg 2008).

This study was conducted in Israel and in Australia. Both societies are built of large waves of immigration and are comprised of a diverse number of ethnic/cultural groups. In addition, Israeli society is further divided into two major groups: Jews and Arabs. Israeli Arabs are the largest minority in Israel, comprising 19.7 % of the overall population in 2006 (Central Bureau of Statistics, Israel 2007). The educational systems for Arabs and Jews are segregated, but both offer the same curriculum and are run by the Ministry of Education. In Australia, state and territory governments are responsible for the provision and major funding of schooling. There is a national curriculum but states/territories implement and conduct the assessment of it. In both countries more females than males successfully complete secondary schooling.

Aims, Sample, and Instrument

The aims of the study were to examine Australian and Israeli mathematics teachers' gendered perceptions of mathematics and to compare the findings by country (Israel and Australia) and by gender within country. A quantitative cross-sectional research design was adopted. Using pre-existing instruments when possible, a survey questionnaire was developed and encompassed a number of affective variables previously identified as contributors to gender differences in mathematics outcomes (see Leder 1992) including: the gendering of mathematics, and attributions for mathematics success and failure. The survey was administered online to voluntary samples of secondary mathematics teachers in both countries.

The bi-national sample was comprised of 181 secondary mathematics teachers: 47 % Israeli (85: 28 M, 57 F), and 53 % Australian (96: 36 M, 60 F). It should be noted that not all teachers responded to every item on the survey, reducing sample sizes for particular analyses. The length of the survey is likely to have contributed to this attrition.

Several demographic and biographical items were included in the survey. These differed slightly by country and, except for respondent gender, are irrelevant to the discussion here. With respect to the affective variables tapped, items from the following pre-existing instruments were used or modified: *Mathematics as a Gendered Domain* (Leder and Forgasz 2002); *Mathematics Attribution Scales* (Fennema et al. 1979). Other previously used items tapping perceptions of mathematics achievement, and differences between boys and girls, were employed.

The affective elements of the online survey included the following:

(i) *Mathematics as a Gendered Domain instrument* (Leder and Forgasz 2002)
Following Mittelberg and Forgasz (2009), only eight items from each of the three subscales – Mathematics as a Male Domain [MD], Mathematics as a Female [FD], and Mathematics as a Neutral Domain [ND] – were used. As in the original scales, five-point Likert-type response formats (Strongly Disagree = 1 to Strongly Agree = 5) were adopted. Sample items:

MD: Boys understand mathematics better than girls do
FD: Girls are more suited than boys to a career in a mathematically-related area
ND: Boys are just as likely as girls to help friends with their mathematics

(ii) *Mathematics Attribution Scales* [MAtS]. The original MAtS are comprised of eight items (four success, and four failure). Each has a stem statement, and four "causes" for the success/failure are listed, one corresponding to each of: ability, effort, task difficulty, and luck/environment; a response to each cause is required (5-point Likert: SD to SA). In this study, a simplified version of MAtS was used to determine teachers' views on the attributions for mathematical success/failure they believed girls and boys would provide. There were four items which were paired to explore for stereotyped beliefs. The teachers were asked to select the most likely reason that a boy/girl would give for success/failure. The items were:

If a boy/girl is successful/unsuccessful at mathematics, which is the <u>most likely</u> reason he/she would give? [Select one of four statements related to each of: ability, effort, task, environment]

Findings

Mathematics as a Gendered Domain: Differences by Gender and Country

Independent groups t-tests were conducted to test for differences in the mean scores (range 1–5) on each the three subscales (MD, FD, and ND) by country and then by gender within country. The t-tests revealed no statistically significant differences by country for each of the three subscales:

MD:	Israel = 2.53	Australia = 2.62
FD:	Israel = 2.61	Australia = 2.44
ND:	Israel = 3.83	Australia = 4.00

These data indicate that on average, and to the same extent, respondents in both countries disagreed that mathematics was a male domain (mean scores < 3), disagreed that mathematics was a female domain, and agreed that it was a neutral domain (mean scores > 3). The results of the independent t-tests by gender within country are shown in Table 2.

The data in Table 2 clearly reveal that the male and female teachers in Australia were of one mind with respect to the gendering of mathematics. In Israel, on the other hand, the male teachers held more gender-stereotyped views than the females: they disagreed less strongly that mathematics was a male domain or a female domain, and agreed less strongly that mathematics was a neutral domain.

Attributions for Success and Failure

The frequencies and percentages of the mathematics teachers in each country selecting each of the four attributions (ability, effort, task, environment) about boys' and girls' attributions for success and for failure are shown in Table 3.

The findings in Table 3 are consistent with the literature on gender differences in boys' and girls' own attributions for success: *ability* was the most frequent response provided by the Israeli (60.8 %) and the Australian teachers (40.7 %) for boys' most likely success attribution; for girls, *effort* was the most frequently provided response by teachers in both countries (Israeli: 53.8 %, Australian: 62.3 %).

Table 2 MD, FD, and ND: sample size, means and T-test results by gender (within country)

		Male		Female			
	Country	*N*	Mean	*N*	Mean	*t*	*p*-value
MD	Israel	19	2.95	39	2.31	3.88	<.001
	Australia	23	2.55	41	2.65		*ns*
FD	Israel	19	2.92	40	2.45	2.97	<.01
	Australia	19	2.45	37	2.44		*ns*
ND	Israel	20	3.61	39	3.93	2.21	<.05
	Australia	20	4.08	41	3.96		*ns*

Table 3 Teachers' beliefs about the success and failure attributions of boys and girls: frequencies and percentages of Israeli and Australian teachers' responses

	Success			Failure	
	Boys' attributions			Boys' attributions	
Attribution	Israel	Australia	Attribution	Israel	Australia
Ability	31 (60.8 %)	22 (40.7 %)	Lack of ability	2 (4.0 %)	13 (24.5 %)
Effort	4 (7.8 %)	14 (25.9 %)	Lack of effort	13 (26.0 %)	19 (35.8 %)
Task	9 (17.6 %)	9 (16.7 %)	Task difficulty	20 (40.0 %)	11 (20.8 %)
Environment	7 (13.7 %)	9 (16.7 %)	Poor environment	15 (30.0 %)	10 (18.9 %)
Total *N*	51	54		50	53

	Success			Failure	
	Girls' attributions			Girls' attributions	
Attribution	Israel	Australia	Attribution	Israel	Australia
Ability	8 (15.4 %)	3 (5.7 %)	Lack of ability	12 (22.6 %)	23 (42.6 %)
Effort	28 (53.8 %)	33 (62.3 %)	Lack of effort	20 (37.7 %)	21 (38.9 %)
Task	5 (9.6 %)	4 (7.5 %)	Task difficulty	10 (18.9 %)	7 (13.0 %)
Environment	11 (21.2 %)	13 (24.5 %)	Poor environment	11 (20.8 %)	3 (5.6 %)
Total *N*	52	53		53	54

Australian teachers' views, but not those of Israeli teachers, were also consistent with the literature on gender differences in boys' and girls' own attributions for failure. For boys, the most frequent response was *lack of effort* (35.8 %), and for girls it was *lack of ability* (38.9 %).

Interestingly, a majority of both the Israeli and the Australian teachers believed that girls would attribute failure to internal factors (lack of ability and lack of effort) – total Israeli 60.3 %; total Australian 81.5 %. Also, a majority of Israeli, but not Australian, teachers believed that boys would attribute failure to external factors (task difficulty and poor environment) – Total 70.0 %. Attributing success to internal factors and failure to external factors is consistent with a *mastery orientation* and considered a functional (likely to lead to future success) attribution pattern (Kloosterman 1990), while attributing failure to internal factors and success to external factors characterises the *learned helpless* individual and is not considered a functional attribution pattern (Leder 1992). The patterns of attribution from teachers in both countries suggest that they would consider boys more likely than girls to have a mastery orientation.

Summary

The cross-national comparisons revealed that in both countries the teachers generally believed that mathematics was a neutral domain. Within country, there were no differences in the views of Australian male and female teachers. Among the Israelis, however, the males appeared to hold more traditionally gender-stereotyped views than their female counterparts. For teachers from both countries, there was consistency with earlier literature (e.g., see Leder 1992) with respect to most likely success attributions: boys to "ability" and girls to "effort". Also echoing previous research, the Australian teachers believed that girls were most likely to attribute failure to "lack of ability" and boys to "lack of effort". Based on response patterns, teachers from both countries are more likely to view boys than girls as having a mastery orientation (Kloosterman 1990), leading to future success in mathematics.

Study 3: Grade 7 Students' and Parents' Gendered Views About Mathematics Learning in Mozambique

Reported here are findings from affective variables incorporated in a larger study aimed at understanding factors influencing mathematics learning outcomes in primary schools in Mozambique. The study was inspired by on-going concerns about persistent patterns of gender differences in mathematics achievement favouring boys among grade 6 students in Mozambique (Saito 2010).

A convenience sample of 300 Grade 7 pupils (134 boys and 166 girls) and 225 parents of these children (109 fathers and 116 mothers) participated in the study. The children attended schools in urban, rural, and remote areas of the Sofala province of Mozambique. The ages of the children varied from 11 to 16, with a mean of 13. The affective variables examined included: perceived achievement in mathematics; perceived usefulness of mathematics; perceptions of boys' and girls' behaviours and dispositions towards mathematics learning; and occupational aspirations. These variables have been identified as influencing students' task-choices, effort expended at tasks, and performance, and are implicated in explanations for gender differences in mathematics learning outcomes (Eccles et al. 1983). The data were gathered from students and their parents using pencil-and-paper surveys. Items related to the affective variables described above were drawn from pre-existing instruments, and other data gathered included biographical and background information.

Findings

Perceived Achievement in Mathematics

Both boys and girls viewed mathematics as the most difficult subject they learnt at school, and physical education was identified as their best subject. Parents also believed mathematics was the most challenging school subject for themselves and for their children. Gender differences in self-perceived achievement were found only in regard to moral and civic education, and favoured girls. No statistically significant differences in these views were found by parent gender, or between parents of sons and parents of daughters.

Perceived Usefulness of Mathematics

All parents believed mathematics was important for their children. However, they did not associate mathematics with technology or jobs. Parents tended to hold utilitarian views about mathematics, that is, that it is about counting, calculating, reasoning, and developing memory skills. The students viewed mathematics as more useful for them than did parents for their children.

The youngest children, children studying in urban schools, children having more educated parents, and children having fewer than three siblings held more positive views about mathematics than the other children. No influence of child gender was evident for perceived usefulness of mathematics. Having electricity at home, piped water, a television set, a computer, internet access, and school uniforms were positively associated with perceived usefulness of mathematics, but not with perceived achievement. Having calculators, cell phones, textbooks for reading and for mathematics, and the language spoken at home were not statistically significantly associated with the children's responses.

Perceptions of Boys' and Girls' Behaviours and Dispositions to Learn Mathematics

To determine the extent to which the students and their parents gender-stereotyped mathematics learning as a male domain, the 30 items from the *Who and mathematics* [W&M] instrument (Leder and Forgasz 2002) were used. Leder and Forgasz (2002) claimed that the 30 items were worded to reflect typical beliefs and/or behaviours towards mathematics learning that had been identified in previous research to be associated with the gendering of mathematics. Consider the item, "Think mathematics will be important in their adult life". Respondents are asked to decide whether the belief or behaviour consistent with the wording of the item was more likely to be true for boys (B), girls (G), or whether there was no difference (ND). For this item, previous research indicated that respondents tended to match the wording of the item with 'boys' (Leder and Forgasz 2002), a response aligned with the traditional view that mathematics is a male domain.

For 17 of the 30 items, the responses of the Grade 7 males were consistent with Leder and Forgasz' (2002) predictions based on previous research. For the Grade 7 females there were only five items: the female students agreed that boys "are asked more questions by the mathematics teacher", "distract other students from their mathematics work", "like using computers to work on mathematics problem", "tease girls if they are good at mathematics", and that girls "get on with their work in class". The grade 7 females' responses to most other items reflected the view of mathematics as a gender-neutral domain.

Parents responded similarly to most items and reflected the traditional view that boys are more suited than girls to learn mathematics (Fathers: 21 items, Mothers: 21 items). Both believed girls would "give up when they find the mathematics problem is too difficult" and that girls would not be good at mathematics. In contrast, they indicated that boys would "enjoy mathematics", "think mathematics will be important in their adult life", and "need mathematics to maximize future employment opportunities". The parents' views were consistent with the view that mathematics is a male domain (see Leder and Forgasz 2002).

Occupational Aspirations

The students were asked which job they would like to have when they are about 30 years of age. Parents were also asked to indicate the job that they would like their children to have in the future. Both students and parents were asked to justify their choices. A higher proportion of girls than boys indicated a preference to engage in people-oriented occupations (e.g., teachers, lawyers, and physicians). In contrast, a higher proportion of boys than girls wanted to be engineers. Previous studies have also reported that females tend to select 'people-oriented' occupations and males 'things-oriented' occupations (Eccles 2007). Interestingly, a higher proportion of mothers wanted their daughters to be engineers than did fathers.

Summary and Recommendations

Both students and parents viewed mathematics as the most difficult school subject. Mothers, fathers, and Grade 7 males tended to view mathematics as more suited to males than to females, while Grade 7 females believed mathematics learning was equally appropriate for boys and girls. Occupational aspirations also reflected a traditional gender divide. The sample involved in this study had both strengths and limitations. The diverse settings in which the data gathering took place (urban, rural, and remote settings) added to the robustness of the findings. The sample size of 300 students at only one grade level from only one province in Mozambique was realistically feasible, yet served as an inevitable constraint on the generalizability of the findings. Nevertheless, the findings have implications for government policy and mathematics teaching in Mozambique. Efforts are necessary to show the relevance and importance of mathematics to parents and students in Mozambique and that mathematics is a field of study that suits every person, regardless of gender or other affiliation.

Study 4: Male and Female Students' Attitudes Towards Mathematics and Calculators

This study was part of a larger Ph.D. research study in which students' learning preferences, beliefs about and attitudes towards mathematics and advanced calculators were explored. The aim of the study reported in this chapter was to investigate if there were any gender differences in the students' attitudes towards

Table 4 Items from Online Survey and Response Formats

Variables and items	Response formats (and coding)
Mathematics competency self-rating (MSR):	1 = Weak, 2 = Below average, 3 = Average, 4 = Good, 5 = Excellent
Currently for mathematics, I consider myself…	
Calculator competency self-rating (CalSR):	1 = Weak, 2 = Below average, 3 = Average, 4 = Good, 5 = Excellent
In terms of GC/CAS calculator[a] skills, I consider myself…	
Calculator enjoyment (Cal_Enj):	1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly agree
I enjoy using calculators to learn mathematics.	
Calculator confidence (Cal_Conf):	1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly agree
I feel confident doing mathematics using calculators.	

[a]"GC" for Singaporean students and "CAS calculator" for Victorian students

mathematics and advanced calculators, for example graphics calculators (GCs) and calculators with computer algebra system (CAS). Senior secondary (grades 11 and 12) students from Singapore and Victoria, Australia were surveyed. In Singapore, GCs are used in all of the senior secondary pre-university mathematics examinations; in Victoria, CAS calculators are used in some of the senior secondary high-stakes mathematics examinations. An anonymous online survey was designed using SurveyMonkey (http://www.surveymonkey.com) and used in the data collection. A summary of the relevant questionnaire items and the response formats is presented in Table 4.

These items were included in the questionnaire developed for the PhD study. A total of 964 Singaporean senior secondary students (63 % females, 37 % males) from four schools responded. Various recruitment strategies were adopted in Victoria because of the initial poor response from a stratified sample of schools (government and non-government) invited to participate. In all, 176 Victorian senior secondary students (69 % females, 31 % males) participated, with 19 % from government schools and 81 % from non-government schools. The small number of Victorian students and the high proportion of students from non-government schools limited the generalisability of the Victorian data. While it is unclear why there were higher proportions of female respondents in both regions, this seems consistent with other survey studies (e.g., Sax et al. 2003).

Results

The Statistical Package for Social Sciences (SPSS) was used to analyse the data. T-tests were used to investigate gender differences in the Singaporean sample, and Mann-Whitney U tests were performed on the Victorian data due to the small sample size. Findings from the items noted in Table 4, including effect sizes, are shown in Table 5.

Table 5 Mean scores and results of statistical comparisons by gender in Singapore and Victoria

		Singapore				Victoria			
	Gender	N	Mean	t	Effect size r[a]	N	Mean	z (Mann-Whitney U test)	Effect size r[a]
MSR (M > F)	F	605	2.79	–4.01***[c]	0.13	118	3.53	NS	
	M	358	**3.08**[b]			48	**3.67**		
CalSR (M > F)	F	604	2.87	–3.59***	0.12	118	3.53	NS	
	M	358	**3.07**			48	**3.79**		
Cal_Enj (M > F)	F	589	3.28	–3.39**	0.11	99	3.33	NS	
	M	349	**3.49**			23	**3.65**		
Cal_Conf (M > F)	F	588	3.08	–4.64***	0.18	99	3.49	3.07**	0.28
	M	349	**3.40**			23	**4.22**		

[a]Effect size for t-test: $r = \sqrt{\dfrac{t^2}{t^2 + df}}$; for Mann-Whitney U test, $r = \dfrac{z}{\sqrt{N}}$ (Field 2005)

[b]For each variable the higher of the two scores (male and female mean scores) is in bold

[c]p-values: *p < .05, **p < .01, ***p < .001

It can be seen in Table 5 that there were differences by region in the patterns of gender differences. In the Singaporean sample there were statistically significant gender differences in students' attitudes towards mathematics and calculators (GCs), and their confidence and enjoyment of calculators. In terms of mathematics and calculator competencies, males, on average, rated themselves slightly above average ($MSR_M = 3.08$, $CalSR_M = 3.07$), whereas females rated themselves slightly below average ($MSR_F = 2.79$, $CalSR_F = 2.87$). Both males and females indicated that they enjoyed using calculators and were confident doing mathematics using calculators, but males had higher mean scores than females ($Cal\_Enj_M = 3.49$, $Cal\_Enj_F = 3.28$, $Cal\_Conf_M = 3.40$, $Cal\_Conf_F = 3.08$).

For the Victorian sample, students generally scored above average in mathematics and calculator competencies, and agreed to the statements about calculator enjoyment and confidence. There was a statistically significant gender difference in students' confidence with doing mathematics using CAS calculators, with males having higher mean score than females ($Cal\_Conf_M = 4.22$, $Cal\_Conf_F = 3.49$). Males had higher mean scores than females for the other variables, but the differences were not statistically significant.

It is interesting to note that although the effect sizes were small for all the gender differences found, the largest effect sizes were for calculator confidence. Also, the effect size for calculator confidence was larger for the Victorian than Singaporean students. The findings that males were more confident than females with using technology are consistent with past research on gender and technology (e.g. Pierce et al. 2007). The findings in the Singaporean data that males had higher mean scores than females for mathematics and calculator competencies are consistent with past studies on Singaporean national examinations (Kaur 1995).

Summary

Overall, these findings reveal that males were more confident users of calculator technologies than females. Since the high stake examinations in both regions have mandatory calculator components, the greater confidence in calculators might be translated into better examination performance. In the Victorian context there were suggestions that males might be advantaged by CAS calculator use in mathematics (Forgasz and Tan 2010). Further studies are needed to examine student outcomes in relation to their attitudes in order to ascertain if this is indeed the case.

Study 5: International Comparisons of Gendered Beliefs About Mathematics and Technology

As noted earlier in this chapter, much research indicates that "negative stereotypes about girls' and women's abilities in mathematics and science persist despite girls' and women's considerable gains in participation and performance in these areas during the last few decades" (Hill et al. 2010, p. 38). Parents and teachers have also been found to hold gender-stereotyped beliefs about and expectations of children's mathematical capabilities (e.g., Tiedemann 2000). Explanatory models for gender differences in mathematics learning outcomes include the views of society at large (see Leder 1992). Yet views from the general public are gathered less often than from stakeholders such as parents and teachers.

The Study: Aim, Method, Instrument, and Sample

The aims of the study were to gather the views of the general public in a variety of countries around the world, to explore whether mathematics continues to be viewed as a male domain, and to make comparisons by country. Facebook was used as the means of participant recruitment (see Tan et al. 2012 for details on how this was done). To maximise response rates, the survey was limited to 15 items. Reported here are findings from six questions related to the gendering of mathematics and technology competence:

Q1. Who are better at mathematics, girls or boys?
Q2. Is it more important for girls or boys to study mathematics?
Q3. Who do parents think are better at mathematics, girls or boys?
Q4. Who do teachers think are better at mathematics, girls or boys?
Q5. Who are better at using calculators, girls or boys?
Q6. Who are better at using computers, girls or boys?

Table 6 Numbers of responses and valid percentages by country

Country	n	Valid (%)	Country	n	Valid (%)	Country	n	Valid (%)
Canada	35	6.4	India	66	12.0	UAE	46	8.4
China	76	13.8	Israel	31	5.6	UK	58	10.5
Egypt	84	15.3	Singapore	35	6.4	Australia	119	21.6

For each item, participants selected: Boys/Girls/Same/Don't know/depends. Responses were received from 784 participants representing 81 countries. There were nine countries – Canada, China, Egypt, India, Israel, Singapore, UAE, UK, and Australia – with at least 30 responses from each; there were 505 responses from these nine countries, representing 70.2 % of all responses. The response frequencies from the nine countries, and the valid percentages represented, are shown in Table 6.

Using SPSS, the responses to the six questions were analysed by country, and chi-square tests were conducted to determine if there were statistically significant differences in the response frequency distributions by country.

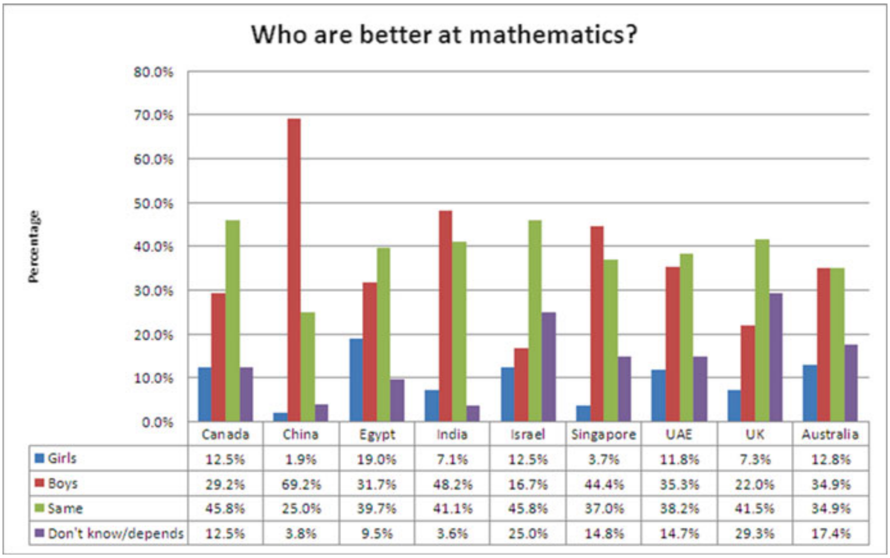
Findings

Questions About the Gendering of Mathematics: Q1, Q2, Q3, and Q4

The frequency distributions of responses by country for Q1 (Who are better at mathematics, girls or boys?), Q2 (Is it more important for girls or boys to study mathematics?), Q3 (Who do parents think are better at mathematics?) and Q4 (Who do teachers think are better at mathematics?) are shown in Figs. 1, 2, 3, and 4 respectively. Statistically significant differences were found in the frequency distributions of responses by country to Q1 ($\chi^2 = 56.0$, df = 24, $p < .001$), Q3 ($\chi^2 = 8.49$, df = 24, $p < .001$), and Q4 ($\chi^2 = 88.23$, df = 24, $p < .001$).

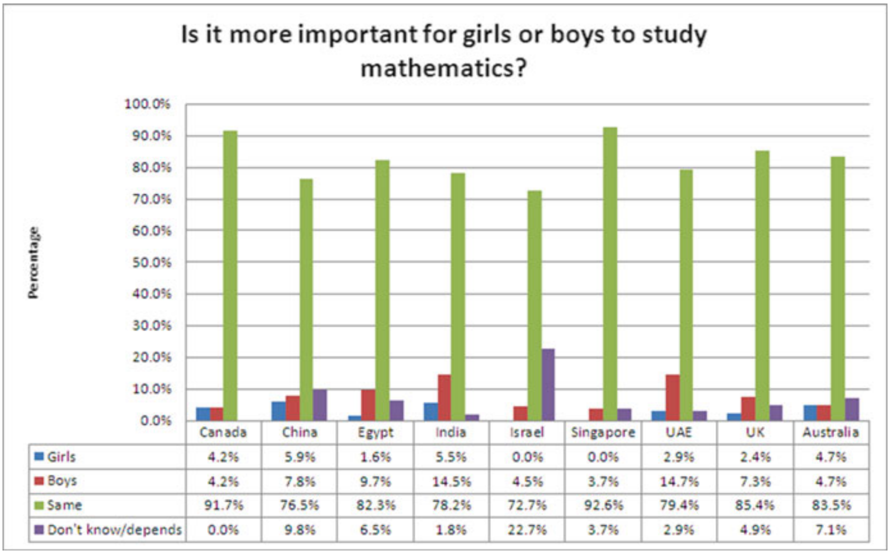
While "same" was the most frequent response to Q1 in five countries (Canada, Egypt, Israel, UAE, and UK), it is clear from Fig. 1 that more participants in each country considered "boys" than considered "girls" to be better at mathematics. Respondents from China held this view, the traditional gender-stereotyped view, more strongly than in other countries. Figure 2 shows that an overwhelming majority in each country considered it equally important for girls and boys to study mathematics (Q2). Interestingly, among the minorities in each country who held gendered views, slightly higher proportions felt that it was more important for boys than for girls to study mathematics.

The pattern of responses to Q3 and Q4 were similar. With respect to beliefs about who parents (Q3) and teachers (Q4) would consider to be better at mathematics, more respondents in each country indicated "boys" than "girls" - see Fig. 3 (Q3) and Fig. 4 (Q4). In response to both questions, respondents from China held to the traditional gender-stereotype more strongly than elsewhere.



	Canada	China	Egypt	India	Israel	Singapore	UAE	UK	Australia
Girls	12.5%	1.9%	19.0%	7.1%	12.5%	3.7%	11.8%	7.3%	12.8%
Boys	29.2%	69.2%	31.7%	48.2%	16.7%	44.4%	35.3%	22.0%	34.9%
Same	45.8%	25.0%	39.7%	41.1%	45.8%	37.0%	38.2%	41.5%	34.9%
Don't know/depends	12.5%	3.8%	9.5%	3.6%	25.0%	14.8%	14.7%	29.3%	17.4%

Fig. 1 Frequency responses by country: who are better at mathematics?



	Canada	China	Egypt	India	Israel	Singapore	UAE	UK	Australia
Girls	4.2%	5.9%	1.6%	5.5%	0.0%	0.0%	2.9%	2.4%	4.7%
Boys	4.2%	7.8%	9.7%	14.5%	4.5%	3.7%	14.7%	7.3%	4.7%
Same	91.7%	76.5%	82.3%	78.2%	72.7%	92.6%	79.4%	85.4%	83.5%
Don't know/depends	0.0%	9.8%	6.5%	1.8%	22.7%	3.7%	2.9%	4.9%	7.1%

Fig. 2 Frequency responses by country: is it more important for girls or boys to study mathematics?

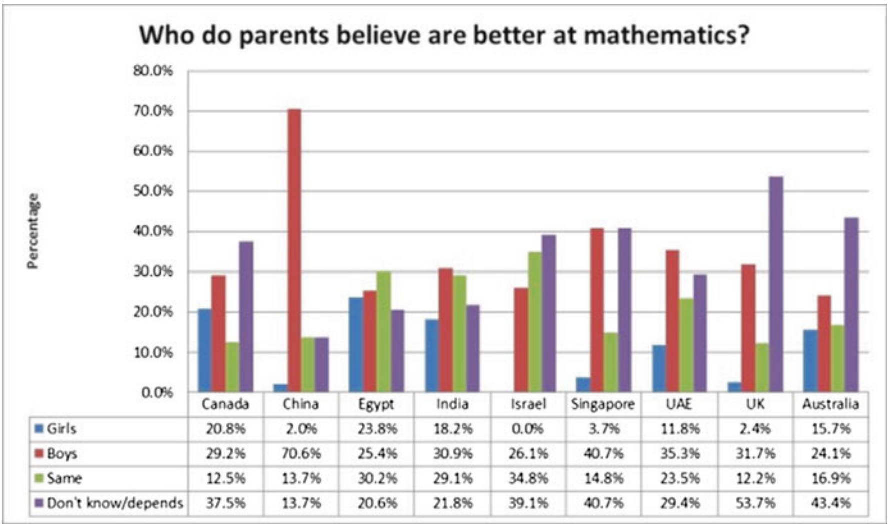


Fig. 3 Frequency responses by country: who do parents think are better at mathematics?

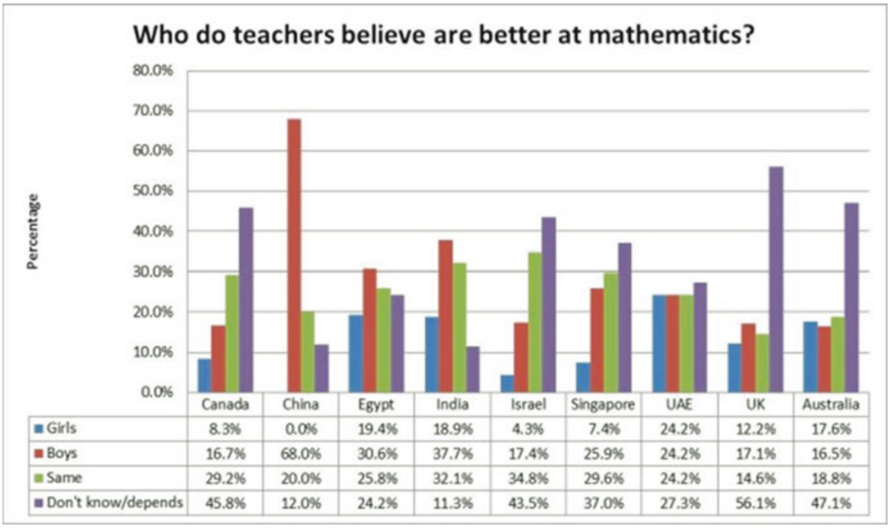


Fig. 4 Frequency responses by country: who do teachers think are better at mathematics?

Competence with Technology: Q5 and Q6

The response frequency distributions by country for Q5 (Who are better at using calculators, girls or boys?) and Q6 (Who are better at using computers, girls or boys?) are shown in Figs. 5 and 6 respectively. The response distributions to both

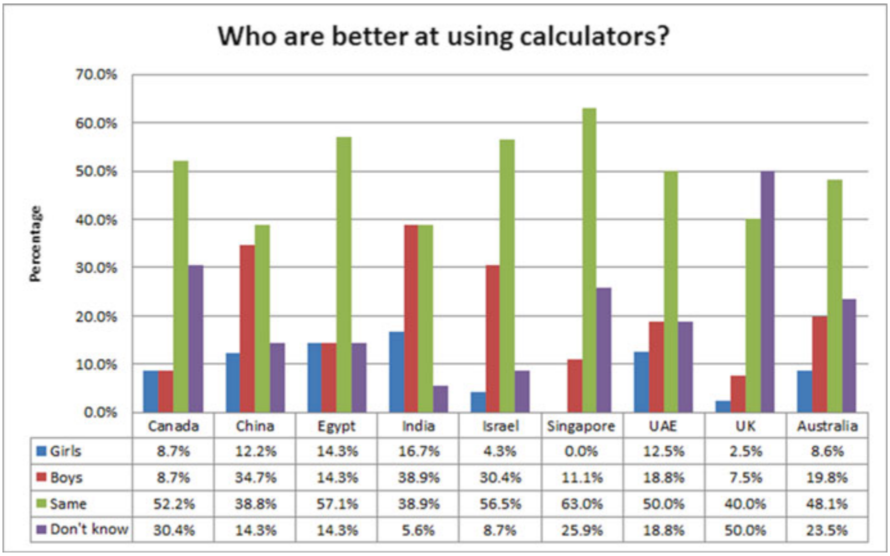


Fig. 5 Frequency responses by country: who are better at using calculators, girls or boys?

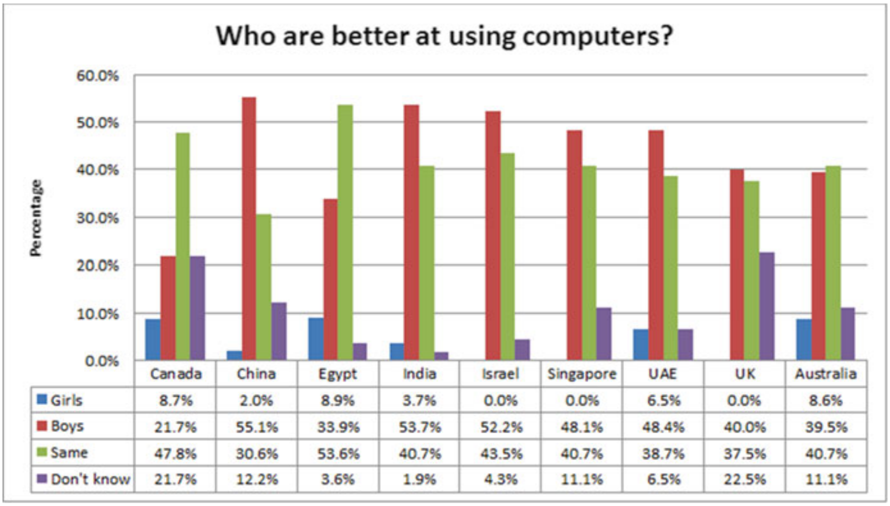


Fig. 6 Frequency responses by country: who are better at using computers, girls or boys?

questions were statistically significantly different: Q5 ($\chi^2=63.9$, df=24, $p<.001$) and Q6 ($\chi^2=38.7$, df=24, $p<.05$).

Interestingly, the patterns of response to Q5 and Q6 about technology were different. Boys were considered more capable than girls with respect to both calculator and computer capability, but this gender-stereotyped view was more strongly held with respect to computers than calculators.

It can be seen in Fig. 5 that in seven countries (Canada, Egypt, China, Israel, Singapore, UAE and Australia), the most frequent response was "same", that is, that boys and girls were considered equally capable with calculators. In Fig. 6, considerably more respondents in each of the nine countries indicated that "boys" rather than "girls" were better at using computers. In fact, in six countries (China, India, Israel, Singapore, UAE and UK) "boys" was the most frequent response. In China, India, and Israel, a majority (ie. over 50 %) of respondents said "boys" were better with computers, indicating that the traditional gender-stereotyped view was very strongly held by respondents from these countries.

Summary

One positive outcome of this study was that in all nine countries there was strong endorsement of mathematics as an important study for all students irrespective of gender. Differences by country were evident, however, when it came to perceptions of boys' and girls' capabilities with mathematics and with technology (calculators and computers). While many people in the nine countries did not distinguish between boys and girls with respect to mathematics or technology use, it was evident that in all countries, to varying extents, it was more likely that the traditional gender-stereotyped view of mathematics as a male domain (that is, that mathematics is more suited to boys than to girls) prevailed. It was noteworthy that there was no item for which the response "girls" had a higher percentage response rate than the response "boys" in any of the nine countries. Participants from China appeared to hold the strongest traditional beliefs about mathematics as a male domain. Participants from English-speaking countries appeared to be more likely than participants from non-English speaking countries to hold gender-neutral beliefs (ie. more likely to respond "same"). Despite the study's limitations – English as the language used in the survey, and the potential age and socio-economic bias inherent to Facebook users – the consistency in the direction of the findings in support of the traditional male stereotype provides strong evidence that gendered perceptions of mathematics are still evident in many parts of the world.

Final Words

Over time, there has been an overwhelming volume of evidence indicating that affect is critical in understanding gender differences in mathematics achievement and participation.

In this chapter we have provided contemporary evidence from five separate research studies covering a range of affective variables with participants of different ages and from different cultural and national contexts to illustrate this point. Collectively, the data presented reveal that the attitudes towards mathematics learning of primary-aged Indigenous female students (Study 1) and of grade 7 female students in Mozambique (Study 3) were less functional (likely to lead to future success) than those of their male counterparts. The parents of the Mozambican students (Study 3), Israeli and Australian mathematics teachers (Study 2), and members of the general public around the world (Study 5) also held views about girls and boys that imply expectations of boys as more likely than girls to have functional dispositions towards mathematics learning. When it came to technology capability, now integral to mathematics learning and science-related occupations, Singaporean and Australian high school boys (Study 4) were found to be more confident in using sophisticated calculators and the general public around the world (Study 5) viewed males as more competent with calculators, although to a lesser extent than they viewed males to be superior with computers.

In summary, beliefs and attitudes that mathematics is still a male domain, that is, that males are more suited than females to pursue studies in mathematics and to follow associated career paths, persist. It also appears that the distribution of these gendered beliefs varies across nations and may be stronger than the differences between males and females within countries. All the data point to the constructed nature of gendered beliefs, cultural and societal drivers and, by implication, the potential for the malleability of these views. What is needed and what can be done?

In our view it is incumbent on mathematics education researchers, whether focussing on affect or not, to consider including gender as an independent variable when designing research studies and when gathering and analysing data. It is also critical to recognize the context in which the research is being conducted and take into consideration the societal and cultural practices that may be influencing affective measures and which, in turn, impact on children's mathematics learning experiences, teachers' pedagogical practices, and students' subsequent mathematics learning outcomes.

It is clear, and endorsed by the United Nations (Commission on the Status of Women 2011), that the *gender problem* has not been overcome, despite evidence of more equitable achievement outcomes and greater levels of educational participation more generally. Why do the attitudes and beliefs of girls, and those of the significant others around them, remain less optimistic in respect of mathematics? There is an imperative for gender and affect to remain on the research agenda and for a re-examination of the means to address and overcome females' persistent mathematical disadvantage.

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