Who can('t) do maths - boys/girls? An international comparison

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Abstract

There has been a long held perception that the field of mathematics is more appropriate for males than for females. The construct, mathematics as a male domain, has been considered a critical variable in explanations for females' under-representation in the most demanding mathematics subjects offered at school and higher education, and in related careers. The widely used Fennema-Sherman Mathematics attitude scales [MAS] consist of nine subscales including Mathematics as a male domain [MD]. It has recently been argued that the content of some of the MD items is anachronistic and that responses to others can no longer be reliably interpreted. Two versions of a new scale, loosely based on the MD, have been developed and trialed in Australia and Singapore with students in grades 7 to 10. In this paper, we present general findings which indicate changes in perceptions about some aspects of the gendering of mathematics, discuss the similarities and differences in the perceptions of students in the two countries, and the implications of the results obtained for equity in mathematics education . The overall findings contribute an important dimension to the debate in contemporary society on concerns about the educational disadvantage of boys.

INTRODUCTION

In the past, studying mathematics was considered more appropriate for males than for females. Historically a range of reasons were put forward for considering women unsuitable for mathematical pursuits:

> Throughout history there has been a recurrent belief that at some fundamental level women were just no good at mathematics. First it was argued that their brains were too small, later that it would compromise their reproductive capacities, still later that their hormones were not compatible with mathematical development. These arguments were buttressed by the underlying belief that mathematics is ultimately a pure meritocracy. Those who have the gift would shine no matter what their background, sex, or race. As a corollary it was assumed that if women were not excelling in the mathematical realm, they must simply lack the talent to compete. (Henrion, 1997, p.xxiv)

It is only in the last thirty years that beliefs about females' inferior mathematical capabilities have been vigorously challenged. Until that time, it was widely accepted that males would outperform females in mathematics and that mathematics and related career fields were male enclaves. Statistical data supported these beliefs. Once it became an optional subject, more boys than girls chose to study mathematics and, on average, females' performance levels were lower than males' (e.g., Leder, 1992).

In the mid 1970s, amid widespread calls for action towards gender equity, girls were identified to be educationally disadvantaged with respect to mathematics. Gender differences in mathematics learning were thought to be the consequences of inadequate educational opportunities, social barriers, biased instructional methods and materials, and more negative attitudes to mathematics shown by females. It was typically assumed that the removal of school and curriculum barriers and, if necessary, the re-socialisation of females, would prove to be fruitful paths to achieve gender equity. In many of the studies published at that time (Leder, 1992), the levels of performance and participation, and the approach to work of males were considered the norms to which females should aspire. Much effort was expended in Western nations in particular to re-dress the inequities (Leder, Forgasz, & Solar, 1996). Founded in liberal feminism, intervention programs focused on females with the aim of raising levels of participation and performance to equal males'.

Changing perspectives on gender and mathematics

By the mid 1980s, different voices were beginning to be heard. Influenced by new theoretical understandings of gender differences in epistemological (Belenky, Clinchy, Goldberger & Tarule, 1986; Baxter Magolda, 1992) and moral development (Gilligan, 1982), gender issues in mathematics education were re-examined from different feminist perspectives (e.g., Burton, 1990; Hanna, 1996; Leder, Forgasz, & Solar, 1996; Rogers & Kaiser, 1995). Many questions were asked. What factors, beyond gender, might be contributing to gender differences in mathematics education? Should young women really strive to become like young men or should the formers' goals, ambitions, and values be celebrated and acknowledged as of equal worth? Should only those conditions and approaches favoured by males be reinforced and accepted? Should the way in which mathematics was being taught and valued be accepted uncritically and be assumed unchangeable? What was the contribution of race/ethnicity, culture and social class in perpetuating gender differences? (e.g., Secada, Fennema & Adajian, 1995; Trentacosta & Kenney, 1997). Liberal feminism's assumptions were being challenged. The presentation of a deficit model of womanhood in which girls and women are positioned as victims with deficit aims and desires were, by some, no longer deemed sufficient or necessary explanations. Traditional measures of students' attitudes to mathematics failed to tap these concerns.

Examinations of longitudinal trends consistently reveal that gender differences in mathematics performance reported in the 1970s seem to be decreasing with time (e.g., Hyde, Fennema & Lamon, 1990). Data from some large scale Australian grade 12 examinations (see Collins & Forgasz, forthcoming) show girls to be outperforming boys. In the *Third International Mathematics and Science Study* [TIMSS] gender differences in the performance levels of students in the middle years of schooling were found in relatively few of the participating countries (Beaton et al., 1996), however. For countries with gender differences, the general trend followed the traditional pattern with boys, on average, scoring higher than girls.

Findings from research studies confirm that students' perceptions about mathematics are also changing (Forgasz, Leder & Gardner, 1999). Some students, females as well as males, now describe females as better at mathematics than males and also as being more prepared to work hard and persevere with the subject. These changing response patterns raise questions about the conceptual frameworks that underpin some frequently used attitude scales.

Several of the early models postulating explanations for the observed gender differences in mathematics learning outcomes favouring males included a range of affective variables, among them the extent to which mathematics is perceived to be a male domain, that is, more appropriate for males than for females (see Leder, 1992). Females who lacked 'sex-role congruency' with mathematics, it was argued, were less likely to persist with mathematical studies (Fennema & Sherman, 1976).

One of the most frequently used instruments for measuring students' perceptions of mathematics as a male domain is the *Mathematics as a male domain* [MD] subscale of the Fennema-Sherman *Mathematics Attitude Scales* (Fennema & Sherman, 1976). Commonly reported findings on students' perceptions of mathematics as a male domain have replicated the early results of Fennema and Sherman (1977) which indicate that the perception of mathematics as a male domain is held more strongly among boys, on average, than among girls. However, Forgasz, Leder and Gardner (1999) recently argued that the wording used in some of the MD items was anachronistic, that the interpretation of responses to other items was questionable, and that some of the assumptions underpinning the MD were invalid. For example, the growing evidence that some people regard mathematics as a female domain (Forgasz, Leder, & Gardner, 1999) is a view not accounted for in the MD.

A new instrument

Two versions of a new instrument aimed at measuring beliefs about the stereotyping of mathematics as a gendered domain - the extent to which it is believed that mathematics is more suited to males, to females, or is regarded as gender-neutral - have been developed in an attempt to address the criticisms of the original MD.

In developing the items for both instruments, we drew on previous research findings about gender issues in mathematics learning - perceptions of ability, gender-appropriateness of careers, general attitude towards mathematics (e.g., enjoyment, interest), environment (e.g., teachers, classrooms, parents), peer effects, effort and persistence, and perceptions about mathematical tasks (e.g., difficulty). We obtained feedback from 10 volunteer mathematics educators and some two dozen volunteer grade 7 to 10 students. Various items were omitted or further modified on the basis of reactions obtained from these groups.

An important difference between the two versions is in the response formats used. For the *Mathematics as a gendered domain* scale, a traditional Likert-type scoring format was adopted - students indicated the extent to which they agreed (or disagreed) with each statement presented. A five-point scoring system was used - strongly disagree (SD) to strongly agree (SA). A score of 1 was assigned to the SD response and a score of 5 to SA. This version of the instrument consisted of 48 items. There were three subscales: *Mathematics as a male domain, Mathematics as a female domain,* and *Mathematics as a neutral domain.* The 16 items making up each subscale were presented in a random order (see Table 1 for sample items) on the survey instrument.

An innovative response format, not inconsistent with that described by Mueller (1986) as a Relative-Belief measure of attitudes, was adopted for the *Who and mathematics* version of the instrument. Thirty statements were presented (See Table 2 for sample items). For each statement, students had to select one of the following responses:

BD - boys definitely more likely than girls

BP - boys probably more likely than girls

ND - no difference between boys and girls

GP - girls probably more likely than boys

GD - girls definitely more likely than boys

Table 1. Selected items from the *Mathematics as a gendered domain* scale

SUBSCALE & FACTOR	ITEM
Male domain - ability	Boys understand mathematics better than girls do
Female domain - career	Girls are more suited than boys to a career in a mathematically-related area
Neutral domain - general	Students who say mathematics is their favourite subject are equally likely to be girls or boys

attitude	
Male domain - environment	Boys are encouraged more than girls to do well in mathematics
Female domain - peers	Boys are distracted from their work in mathematics classes more than are girls
Neutral domain - effort	Girls and boys are just as likely to be lazy in mathematics classes
Male domain - task	Boys, more than girls, like challenging mathematics problems

Table 2. Selected items from the *Who & mathematics* instrument

FACTOR	ITEM
Ability	Find maths easy
Career	Think maths will be important in their adult life
General attitude	Enjoy mathematics
Environment	Parents think it is important for them to study maths
Peers	Tease girls if they are good at maths
Effort	Have to work hard to do well
Task	Like challenging maths problems

Common to both versions were the following questions:

1. How good are you at mathematics [HGM]? There were five response categories: excellent (scored at 5) - weak (scored at 1).
2. Are you planning on studying mathematics in grade 12? Three responses were possible: Yes, No, or Unsure.
3. A space was left at the end of each questionnaire in which students were asked to supply any comments they wished to make

In the first trial of the new instruments, approximately 400 grade 7-10 students from Victorian schools completed each questionnaire. Statistical tests were conducted to determine the effectiveness of the different items and formats and also to examine the data for possible gender and grade level differences. In preparation for the second trial, psychometrically unsatisfactory items were deleted from the original questionnaires and others added to produce the second versions of the instruments. The modified questionnaires were administered to approximately 1700 students from eight co-educational schools situated in the metropolitan and country regions of Victoria. Half the students in each class completed version 1; the other version 2 of the instrument.

Selected results from the first trial of the *Who and mathematics* instrument have been summarised in Forgasz, Leder and Barkatsis (1998; 1999). Changing patterns of beliefs about the gendering of mathematics were found. An examination of the data from two schools with majority enrolments of identifiable ethnic groups - one Jewish and one Greek - revealed differences in views of students from the two schools compared to students from the other schools in the sample. In the school associated with the Jewish community, students were generally less stereotyped in their views but reflected more traditionally stereotyped beliefs that mathematics was more likely to feature in the future careers of males than of females. At the school affiliated with the Greek community the image of mathematics classrooms portrayed was more strongly consistent with a 'male enclave' than could be inferred from the responses of students at the other schools. It was concluded that culture appeared to have contributed to the shaping of students' belief systems.

For the second trial, students from one school in Singapore were invited to complete the questionnaires. The TIMSS results for Australia and Singapore were the impetus for including the Singaporean sample in the trial. Australia and Singapore were among the countries for which there were no statistically significant gender differences in performance, although the Singaporean students outperformed the Australians. Despite their higher achievement scores, the attitudinal data gathered in the TIMSS revealed that the Singaporean students held more negative attitudes towards mathematics than did the Australians (Beaton et al., 1996). Beliefs about the gendering of mathematics were not tapped in the TIMMS. We were interested to know if the changing pattern of beliefs and the effects of the interaction of culture and gender evident in the first trial of the new instruments were replicable.

Since data were gathered from only one very large co-educational school in Singapore, the data from only one Australian school - the school providing the largest sample of students - were used to compare the findings from the two countries.

THE STUDY

Sample and methods

In Australia and Singapore, the two versions of the new instrument were administered to students in grades 7-10. The sample sizes are summarised in Table 3.

Table 3. Sample sizes

	Mathematics as a gendered domain			***Who and mathematics***		
Country	**Female**	**Male**	**?**	**Female**	**Male**	**?**
Australia	148	128	3	156	113	3
Singapore	261	264	-	265	265	-

Data from both versions of the instrument were analysed using $SPSS_{PC}$.

Results and discussion

Mathematics as a gendered domain (Version 1 of the new instrument)

For each of the three subscales - *Mathematics as a male domain*, *Mathematics as a female domain*, and *Mathematics as a neutral domain*, statistical tests were conducted to compare the responses of boys and girls and to examine if there were differences in the views of students in the two countries.

The results of the statistical analyses (2-way ANOVAs) exploring for differences in mean scores on each subscale by country and gender are shown in Table 4. Statistically significant results are indicated.

Table 4. Mean scores[1] by country and gender

MALE DOMAIN		**FEMALE DOMAIN**		**NEUTRAL DOMAIN**	
Australia	***Singapore***	***Australia***	***Singapore***	***Australia***	***Singapore***
2.20	2.59***	2.68	2.63	3.88	3.94
Female	***Male***	***Female***	***Male***	***Female***	***Male***
2.24	2.70***	2.73	2.55***	3.98	3.85***

1 Scores recorded are the means of the mean item score on each subscale

p-levels: * = <.05; ** = <.01; *** = <.001

The results shown in Table 4 can be summarised as follows:

***Male domain**:* Students did not stereotype mathematics strongly as a male domain (mean scores < 3). However:

- Singaporean students believed more strongly than Australian students that mathematics was a male domain. For the Singaporean students, this was true for the females and for the males (see Table 5)
- males believed more strongly than females that mathematics was a male domain

***Female domain**:* Students did not stereotype mathematics strongly as a female domain (mean scores < 3). However:

- females believed more strongly than males that mathematics was a female domain.

Interestingly, mathematics was stereotyped slightly more strongly as a female domain than as a male domain by students in both countries.

***Neutral domain**:* In general, students strongly agreed that mathematics was a gender neutral domain (mean scores > 3). However:

- males were less convinced of this than were females

We were also interested to know if there were differences in the views of: males and females within each country. The results of these analyses (independent groups t-tests) are shown in Table 5.

Table 5. Mean scores for Australian and Singaporean males and females

	MALE DOMAIN		FEMALE DOMAIN		NEUTRAL DOMAIN	
	Female	***Male***	***Female***	***Male***	***Female***	***Male***
Australia	2.03	2.38***	2.75	2.60	3.90	3.86
Singapore	2.33	2.85***	2.72	2.54***	4.03	3.84***

The data on Table 5 can be summarised as follows:

Among Australian students, males were:

- more convinced than females that mathematics is a male domain

Among Singaporean students, males were:

- more convinced than females that mathematics is a male domain
- less convinced than females that mathematics is a female domain
- less convinced than females that mathematics is a neutral domain

Who and mathematics (Version 2 of the instrument)

Responses to each of the 30 items on this version of the instrument were examined separately. The data were examined in two ways.

1. Scores were assigned to each response category as follows:

BD=1 BP=2 ND=3 GP=4 GD=5

Mean scores were then calculated. The mean score indicates whether the 'average' belief associated with the wording of the item was in the direction "boys are more likely than girls to..." (mean scores<3) or in the direction "girls are more likely than boys to..." (mean scores>3).

2. The frequency distributions for the five response categories were examined. Of particular interest was the percentage response to the ND (no difference between boys and girls) category.

Mean scores

The mean scores on each of the 30 items for Australian and Singaporean students are shown in Figure 1. Items with means>3 appear on the right of the vertical line (which passes through the score of 3) and items with means<3 are on the left.

PLACE FIGURE 1 HERE

As can be seen in Figure 1, there were 15 items (Items 2, 3, 4, 7, 8, , 10, 12, 16, 17, 22, 24, 25, 26, 28 and 30) which both the Australian and Singaporean students agreed were more likely to apply either to boys or to girls, though the two samples often differed in the intensity of their ratings.

Students in both countries considered "boys more likely than girls to":

- be asked more questions by the mathematics teacher (Item 3)
- give up when they find a mathematics question is too difficult (Item 4)
- need mathematics to maximise further employment opportunities (Item 10)
- be encouraged by the mathematics teacher to do well (Item 12)
- distract other students from their mathematics work (Item 16)
- get wrong answers in mathematics (Item 17)
- like using computers to work on mathematics problems (Item 24)
- have teachers spend more time with them (Item 25)
- consider mathematics to be boring (Item 26)
- tease girls if they are good at mathematics (Item 30)

and "girls more likely than boys to":

- think it is important to understand the work in mathematics (Item 2)
- care about doing well in mathematics (Item 7)
- think they did not work hard enough if they do not do well in mathematics (Item 8)
- worry if they do not do well in mathematics (Item 22)
- get on with their work in class (Item 28)

For many of these items, students' beliefs are consistent with those reported in earlier research.

For 15 of the 30 items students in Australia and Singapore held beliefs in opposite directions (Items 1, 5, 6, 9, 11, 13, 14, 15, 18, 19, 20, 21, 23, 27, and 29), though again there was considerable variation in the strength with which they indicated the descriptor to be sex-linked. On these items,

Australian students believed "girls were more likely than boys to..." (means>3) and Singaporean students believed "boys were more likely than girls to..." (means<3):

- consider mathematics their favourite subject (Item 1)
- enjoy mathematics (Item 6)
- have parents who would be disappointed if they did not do well in mathematics (Item 9)
- like challenging mathematics problems (Item 11)
- have mathematics teachers think they will do well (Item 13)
- think mathematics will be important in their adult lives (Item 14)
- expect to do well (Item 15)
- find mathematics easy (Item 18)
- have parents think it important for them to study mathematics (Item 19)
- think mathematics is interesting (Item 29)

Conversely, Australian students believed "boys were more likely than girls to..." (means<3) and Singaporean students believed "girls were more likely than boys to..." (means>3):

- have to work hard in mathematics to do well (Item 5)
- need more help in mathematics (Item 20)
- tease boys if they are good at mathematics (item 21)
- not be good at mathematics (Item 23)
- find mathematics difficult (Item 27)

It is noteworthy that the Singaporean students' views are generally consistent with those most commonly reported in earlier research studies. The views endorsed by the Australians students challenge research findings from the past.

The ND (no difference between boys and girls) response category

In both countries, over 50% of the students responded ND to the majority of the 30 items. More than 50% ND responses were made to 19 items by the Australian students and to 24 items by the Singaporeans. These findings are consistent with the higher mean scores found on the other version of the instrument for the *Mathematics as a neutral domain* subscale than for the male or female domain subscales.

Self-ratings of mathematics achievement

The question "How good are you at mathematics?" [HGM] was asked on both versions of the new instrument. Students recorded their responses on a 5-point scale: 1=Weak to 5=Excellent. Mean scores were calculated and are shown in Table 6. Statistically significant differences by country and by gender are indicated.

Table 6. Mean scores for Australian and Singaporean males and females

	***Mathematics as a gendered domain* version**			***Who & mathematics* version**		
	All	***Female***	***Male***	***All***	***Female***	***Male***
Australia	3.35	3.34	3.35	3.48	3.53	3.42
Singapore	3.09^{+++}	2.98	3.20**	3.22^{+++}	3.15	3.29*

Statistically significant differences by country: $^{+++}$ p<.001

Statistically significant gender differences: * p<.05 ** p<.01

The HGM results from both instruments indicate that:

- Australian students' self-ratings of mathematics achievement were higher than Singaporean students'
- Among the Singaporean students: males' self-ratings were higher than females'
- There was no significant gender difference between the self-ratings of Australian males and females

The pattern of gender difference in self-ratings among Singaporean students follows patterns generally reported in the literature. For Australian students the findings reveal a significant shift in beliefs; in the past, males were found to rate their achievements higher than females.

CONCLUSIONS

What have we learnt from the data?

In the discussion that ensues, it must be noted that the findings from students attending only one school in each country were analysed and reported in this paper. Furthermore, we have included all items in our analyses, even those on which the differences were very small. Hence all conclusions are to be cautiously interpreted.

A very positive outcome of this study was that students in Australia and Singapore generally believe much more strongly that mathematics is a neutral domain than either a male or a female domain. Data from the *Mathematics as a gendered domain* version of the instrument indicated that Australian students appeared to believe this to a greater extent than their Singaporean counterparts. Overall, findings from this version of the instrument indicated that females held less stereotyped views than males. Although beliefs were not strong that mathematics was a male domain, in both countries males were more convinced that this was the case than were females. This latter finding is consistent with earlier reported research results.

An unexpected finding that is worthy of further exploration was that mathematics was stereotyped more strongly as a female domain than as a male domain, except among Singaporean males. This finding among Australian students may reflect students' scores on large scale examinations such as the Victorian Certificate of Education (Collins & Forgasz, forthcoming) and a growing perception that boys are now the disadvantaged group academically, a view receiving much media attention (see Forgasz, 1999).

With the majority of students on the majority of items in both countries responding that there was 'no difference between boys and girls' [ND], the *Who and mathematics* version of the scale confirmed that the majority of students do not gender stereotype mathematics. However, there were different patterns of responses among those who did stereotype mathematics. The differences were in the directions - 'girls more likely than boys' or 'boys more likely than girls' - and by country. In general, Singaporean students' responses were in the directions consistent with previous research findings. Among the Australian students, many response patterns reflect a changing pattern of beliefs, although some responses echoed those of the past. However, it could now be argued that in Australia boys are perceived (by both males and females) to have some of the characteristics previously identified as disadvantaging girls - perceptions of lower ability than girls, general poorer attitude towards mathematics (interest, enjoyment) than girls, and lower personal expectations of success. Our larger sample of Australian students should provide more information regarding these findings.

From previous research in the field of gender issues in mathematics education, we know that attitudes and beliefs can impact on individuals' performance levels and influence decisions to persist with studies in mathematics at higher levels. The TIMMS results for students in the middle years of schooling indicated no gender differences in the performance levels of girls and boys in either Australia or Singapore. Yet, our results revealed differences in the extent and directions to which students in each country stereotype mathematics. The data gathered in this study cannot provide explanations for the findings. Perhaps there are cultural differences which partially account for the differences in students' responses. There may also be differences in parents' and teachers' expectations of students. Perhaps variations in curricular emphases, teaching methods, and assessment strategies in the two countries are implicated.

FINAL WORDS

Findings from the present study appear to lend support to the hypothesis that gender and culture interact to influence students' beliefs about the gender-appropriateness of mathematics. However, more work is needed to confirm the findings reported here and to explore patterns among students from a range of different cultural backgrounds. If equity in mathematics learning outcomes - performance levels and participation rates - is to be attained, further research is needed to pinpoint the often subtle factors contributing to beliefs related to the stereotyping of mathematics.

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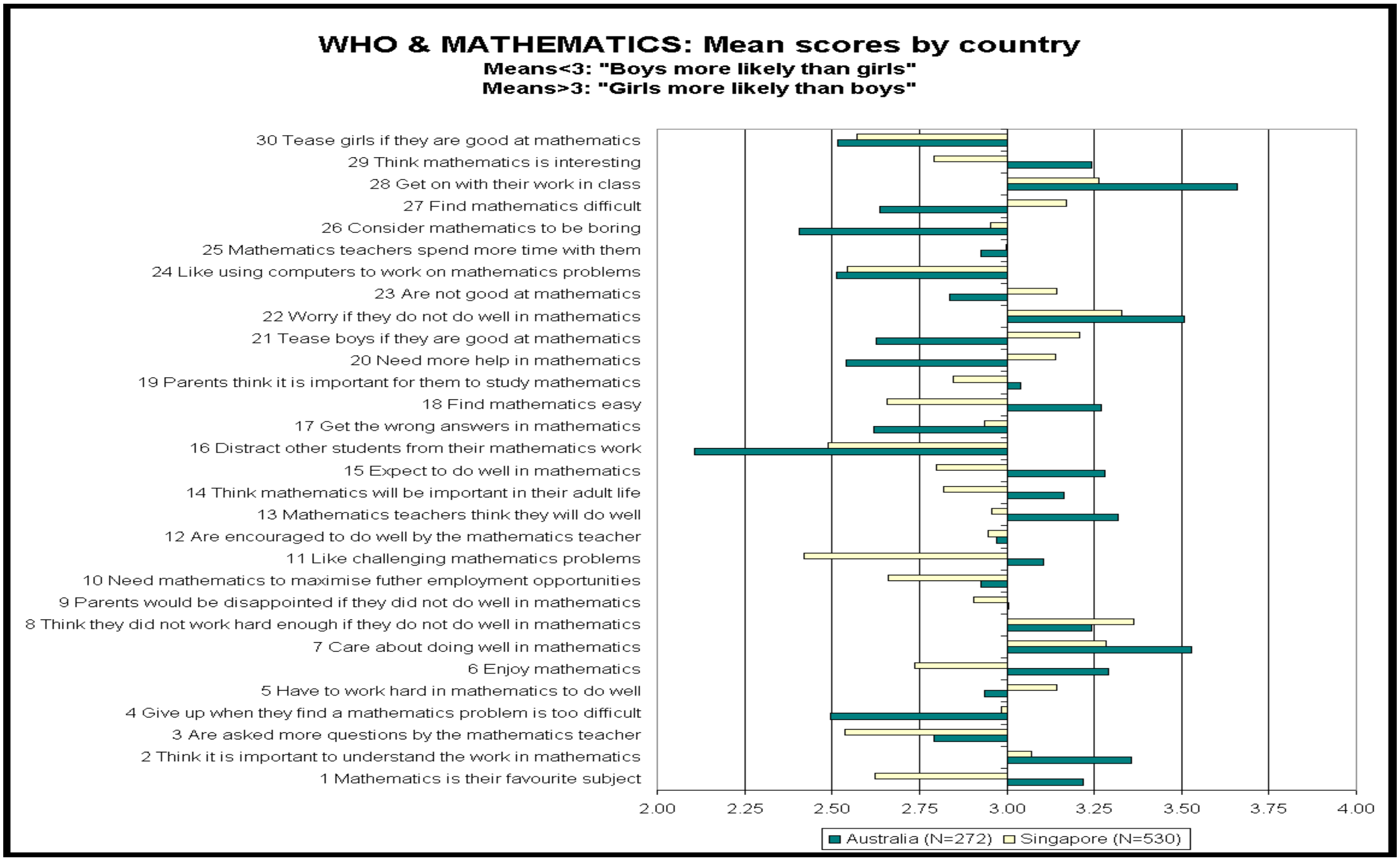

Figure 1. Mean scores per item by country