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ABSTRACT

In this paper, findings from two new instruments measuring the extent to which mathematics is stereotyped as a gendered domain are reported. The instruments were administered to Australian secondary students (grades 7-10) and to pre-service teachers. Comparisons were made with data from similar American samples of students and pre-service teachers who completed the same instruments. The Australian results revealed that students' beliefs about mathematics as a male domain were inconsistent with previous findings in the field; the pre-service teachers' views of the students' beliefs were more in-line with earlier research. There was remarkable similarity in the patterns of the results from Australia and the USA. (Author)

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Mathematics: Still a Male Domain? Australian Findings[1]

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Abstract

In this paper, findings from two new instruments measuring the extent to which mathematics is stereotyped as a gendered domain are reported. The instruments were administered to Australian secondary students (grades 7-10) and to pre-service teachers. Comparisons were made with data from similar American samples of students and pre-service teachers who completed the same instruments. The Australian results revealed that students' beliefs about mathematics as a male domain were inconsistent with previous findings in the field; the pre-service teachers' views of the students' beliefs were more in-line with earlier research. There was remarkable similarity in the patterns of the results from Australia and the USA..

Introduction

As described in detail by Leder (2001), two new instruments were designed to measure the extent to which mathematics was stereotyped as a gendered domain – *Mathematics as a gendered domain* and *Who and mathematics*. The instruments were developed and trialed in Australia. They were initially administered to secondary students in grades 7-10 and then, with slightly modified instructions, to pre-service teachers (university students training to become classroom teachers). Colleagues in the USA administered the same instruments to similar cohorts of secondary students and pre-service teachers (Kloosterman, Tassell, & Ponniah, 2001).

It should be noted that the instructions to the pre-service teachers were slightly different from the directions given to the secondary students (see Leder, 2001). Students were asked for their reactions to the items. The pre-service teachers were asked to think about what takes place in contemporary high school mathematics classrooms as they responded to the items. Hence with respect to the responses to the *Who and mathematics* instrument in particular, when comparisons are made between the students' and the pre-service teachers' responses, the findings reflect differences in students' beliefs and pre-service teachers' views of the students' beliefs.

In this paper, the findings from the Australian samples are presented and the similarities and differences between the Australian and USA samples are discussed.

Results

The results from the administration of the *Mathematics as a gendered domain* instrument are presented and discussed first, followed by the results from the *Who and mathematics* instrument.

Mathematics as a gendered domain

Secondary students

Australian sample size: N= 846 (408M, 412F, 26?) grade 7-10 students

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The psychometric properties of the *Mathematics as a gendered domain* instrument, based on its administration to the Australian secondary students, are presented and described in detail by Leder (2001).

The data from the Australian secondary students were examined for gender differences using independent groups t-tests. The results are shown in Table 1[2] together with the results from the US sample.

Table 1. Means, standard deviations and independent group t-test results by gender for *Mathematics as a gendered domain*: Australian and USA secondary students.

		MALES		FEMALES		
SUBSCALE[1]		**Mean**	**SD**	**Mean**	**SD**	**t (sig.level)**
Neutral Domain	***Aus***	3.76	.56	3.92	.54	3.8***
	USA	3.69	.64	4.02	.55	6.2**
Male Domain	***Aus***	2.54	.68	2.12	.59	9.0***
	USA	2.72	.76	2.11	.68	9.4**
Female Domain	***Aus***	2.71	.72	2.69	.68	.28
	USA	2.71	.69	2.56	.72	2.3*

1 The score for each subscale ranges from 1 to 5 with 1 indicating strong disagreement and 5 indicating strong agreement.
Levels of statistical significance for t: * p<.05 ** p<.01 ***p<.001

As can be seen in Table 1, the Australian males and females both generally disagreed that mathematics was either a male or a female domain (mean scores < 3) and agreed that mathematics was a neutral domain (mean scores > 3). Statistically significant gender differences were found on two subscales – *male domain* and *neutral domain*. On average, males believed more strongly than females that mathematics was a *male domain* and females believed more strongly than males that mathematics was a *neutral domain*. There were no statistically significant difference in males' and females' perceptions of mathematics as a *female domain*.

Australian and US[3] data

USA sample size: N = 507 (246M, 261F)[4] grade 7-12 students

The comparisons between the Australian (grades 7-10) and USA (grades 7-12) students can be seen in Table 1 and in Figure 1.

Of particular interest are the striking similarities in the patterns of the results from Australia and the USA, clearly illustrated in Figure 1. In both countries:

- males and females believed most strongly that mathematics was a neutral domain
- males and females generally disagreed that mathematics was either a male or a female domain (scores < 3)

2 The numbers of Australian students providing complete data for the calculation of mean scores for the three scale were: M: 357-367; F: 369-374

3 The US data were gathered by Peter Kloosterman and his colleagues and are presented in Kloosterman, Tassell, & Ponniah (2001)

4 The numbers of USA students providing complete data for the calculation of mean scores for the three scale were: M: 233-236; F: 247-251

- the directions of the gender differences in the scoring patterns were the same

The notable difference in the findings was that among the USA students, the females believed less strongly (i.e. disagreed more) than the males that mathematics was a female domain. Among the Australians, there was no gender difference on the *female domain* subscale.

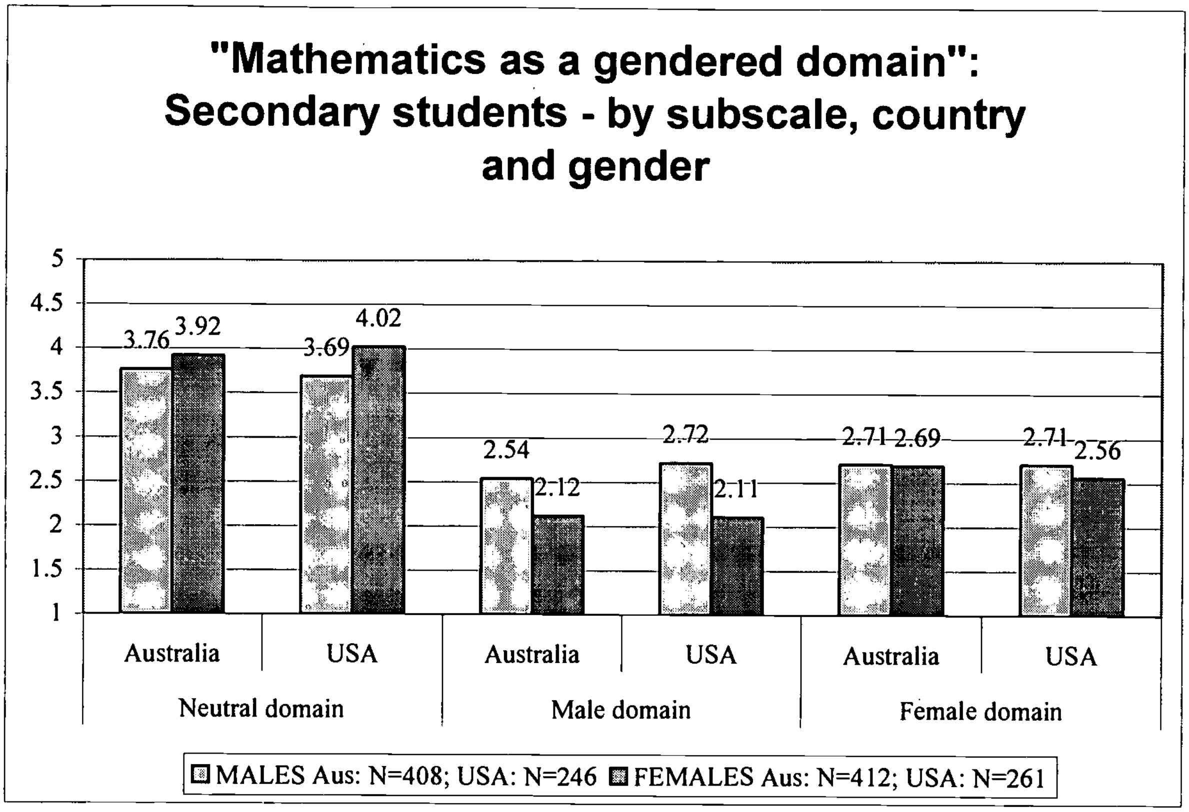

Figure 1. Mean scores on the three subscales of the *Mathematics as a gendered domain* scale by gender and country.

Pre-service teachers

The sample sizes of the pre-service teachers were:

Australia: 386 (81M, 305F) USA: 92 (11M, 81F)

Because of the large gender imbalance in both countries, analyses by gender were not conducted. As a consequence of the numerical dominance of females, it should be noted that the findings described below are heavily influenced by their responses.

Independent groups t-tests were conducted to examine for differences in mean scores for the pre-service teachers by country. The results are recorded in Table 2.

The data in Table 2 indicate that the pre-service teachers in both countries:

- believed most strongly that mathematics was a neutral domain
- generally disagreed that mathematics was either a male or a female domain (scores < 3)

The statistically significant difference for the *female domain* subscale indicated that the US pre-service teachers disagreed more strongly than the Australians that mathematics was a female domain.

Table 2. Means, standard deviations and independent group t-test results by country for *Mathematics as a Gendered Domain*: Australian and US pre-service teachers

	AUSTRALIA		USA		
SUBSCALE[1]	**Mean**	**SD**	**Mean**	**SD**	**t (sig.level)**
Neutral Domain	3.83	.48	3.89	.50	1.0
Male Domain	2.39	.62	2.42	.68	.5
Female Domain	2.49	.54	2.31	.45	2.8**

[1] The score for each subscale ranges from 1 to 5 with 1 indicating strong disagreement and 5 indicating strong agreement.

Level of statistical significance for t: ** p<.01

When the Australian pre-service teachers' results (Table 2) were compared to those of the Australian male and female students (Table 1), the pre-service teachers appeared to perceive mathematics to be:

- more stereotyped as a neutral domain, and less stereotyped as a male domain and as a female domain than did the male students and,
- more stereotyped as a male domain and less stereotyped as a neutral domain and as a female domain than did the female students.

Since the pre-service teacher data are greatly influenced by female responses, the comparisons with the female students are of particular interest. It seems that the pre-service teachers' views are more closely aligned with a more traditional perspective of mathematics as a "male domain" than was evident among the female high school students. It was also noteworthy that the pre-service teachers disagreed more strongly than the male students that mathematics was a female domain.

Who and mathematics

The *Who and mathematics* scale, its five item response categories – 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) and GD (girls definitely more likely than boys) – and the method for scoring the items are described in detail by Leder (2001).

Secondary students

Australian sample size: N = 861 (436M, 402F, 23?)[5] grade 7-10 students.

It is important to point out that when the distributions of the responses to each item were examined, the most frequent response category in the vast majority of cases was ND – "no difference between boys and girls". This indicates that most students did not gender-stereotype those aspects of mathematics tapped in the wording of the majority of the items on this instrument. This pattern was also evident in the response patterns for the pre-service teachers.

Leder (2001) presented a table in which the directions for responses to the 30 scale items, based on previous research, were illustrated. In Table 3, the 30 items, the predicted directions from research and the findings for the entire Australian sample of grade 7-10 students are shown. Items for which statistically significant gender differences were found are shown with asterisks.

[5] The numbers of Australian students providing complete data for the calculation of mean scores for each item varied as follows: M: 426-434; F: 397-401

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Table 3. Predictions from previous research (Pred) and findings from Australian grade 7-10 students (***Find - Ital. bld***)

	ITEM	Pred	***Find***		ITEM	Pred	***Find***
1	Mathematics is their favourite subject	M	***F***	16	Distract other students from their mathematics work	M	***M***
2*	Think it is important to understand the work in mathematics	F	***F***	17*	Get the wrong answers in mathematics	F	***M***
3*	Are asked more questions by the mathematics teacher	M	***M***	18	Find mathematics easy	M	***F***
4*	Give up when they find a mathematics problem is too difficult	F	***M***	19*	Parents think it is important for them to study mathematics	M	***nd***
5*	Have to work hard in mathematics to do well	F	***M***	20*	Need more help in mathematics	F	***M***
6	Enjoy mathematics	M	***F***	21	Tease boys if they are good at mathematics	M	***M***
7*	Care about doing well in mathematics	M/F	***F***	22*	Worry if they do not do well in mathematics	M/F	***F***
8*	Think they did not work hard enough if do not do well in mathematics	M	***F***	23*	Are not good at mathematics	F	***M***
9*	Parents would be disappointed if they do not do well in mathematics	M	***F***	24	Like using computers to work on mathematics problems	M	***M***
10*	Need mathematics to maximise future employment opportunities	M	***M***	25	Mathematics teachers spend more time with them	M	***nd***
11	Like challenging mathematics problems	M	***nd***	26*	Consider mathematics to be boring	F	***M***
12	Are encouraged to do well by the mathematics teacher	M	***nd***	27*	Find mathematics difficult	F	***M***
13	Mathematics teachers thinks they will do well	M	***F***	28	Get on with their work in class	F	***F***
14*	Think mathematics will be important in their adult life	M	***F***	29*	Think mathematics is interesting	M	***F***
15*	Expect to do well in mathematics	M	***F***	30*	Tease girls if they are good at mathematics	M	***M***

NB. * Items with statistically significant gender differences
Shaded items: findings consistent with predictions from previous research

As shown in Table 3, there were only eight items (2, 3, 10, 16, 21, 24, 28, & 30) for which the response directions were consistent with previous findings. These items were generally related to the learning environment and to peers. For example, boys were believed more likely than girls to be asked more questions by the teacher (Item 3), to distract others from their work (Item 16), to tease both boys (Item 21) and girls (Item 30) who did well in mathematics, and to like using computers to solve mathematics problems (Item 24).

That students' beliefs on so many items were inconsistent with previous research implies a fairly recent change in gendered perceptions related to mathematics education. For example, in the past, boys were believed more likely than girls to have natural ability for mathematics, to enjoy mathematics and to find it interesting. The Australian findings reveal that, on average, students now consider boys more likely than girls to give up when they find a problem too challenging (Item 4), to find mathematics difficult (Items 27 & 18), and to need additional help (Item 20). Girls were considered more likely than boys to enjoy mathematics (Item 6) and find mathematics interesting (Item 29).

Gender differences in responses

Gender differences in the responses of the Australian secondary students are illustrated in Figure 2. The line down the middle of the graph is at the value 3, the mid-point of the range of possible mean scores. Bars to the left of 3 represent items for which the mean score was less than 3 and indicate

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that, on average, the students believed "boys were more likely than girls to...". Bars to the right of 3 represent items with mean scores greater than 3 and indicate that the students, on average, believed that "girls were more likely than boys to...".

PLACE FIGURE 2 ABOUT HERE

As can be seen from the directions of the 'bars' on Figure 2 (and in Table 5 below), male and female students were consistent in their beliefs whether it was boys or girls who were more likely to match the wording for 22 of the 30 items. The extent of agreement varied considerably on several of these items. The statistical significance of gender differences was assessed by independent groups t-tests. It was found, for example, that the female students were more convinced than the males that girls 'think it is important to understand the work' (Item 2, p<.001), that they 'worry if they do not do well in mathematics' (Item 22, p<.001), and that boys 'teased girls who were good at mathematics' (Item 30, p<.001). Males were more convinced than females that boys 'need more help with mathematics' (Item 20, p<.001) and that they 'give up when they find a mathematics problem too difficult' (Item 4, p<.01).

Australian and US comparisons

USA sample size: N = 527 (240M, 286F, 1?)[6] grade 7-12 students.

The means, standard deviations and independent groups t-test results by gender for each item on the *Who and mathematics* instrument for secondary students in Australia and the USA are presented in Table 4.

Table 4. Australian and USA secondary students: Means, standard deviations and t-test results by gender for the items on the *Who and mathematics* instrument

		Males		Females		
Item #		**Mean**	**SD**	**Mean**	**SD**	***t (sig. level)***
1 Mathematics is their favourite subject	***Aus***	3.16	.75	3.09	.64	1.4
	USA	3.10	.87	2.99	.72	1.5
2 Think it is important to understand the work in mathematics	***Aus***	3.12	.77	3.47	.73	6.6***
	USA	3.09	.90	3.34	.73	3.5**
3 Are asked more questions by the mathematics teacher	***Aus***	2.77	1.02	2.92	.85	2.3*
	USA	3.03	.90	2.98	.90	0.6
4 Give up when they find a mathematics problem is too difficult	***Aus***	2.39	.99	2.59	.95	3.0**
	USA	2.68	1.13	2.60	.97	0.9
5 Have to work hard in mathematics to do well	***Aus***	2.79	.88	3.08	.69	5.4***
	USA	2.92	.87	3.11	.66	2.8**
6 Enjoy mathematics	***Aus***	3.27	.90	3.18	.64	1.7

6 The numbers of USA students providing complete data for the calculation of mean scores for each item varied as follows: M: 237-240; F283-286

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Item #		Males		Females		
		Mean	SD	Mean	SD	*t (sig. level)*
	USA	3.15	.90	3.03	.70	1.7
7 Care about doing well in mathematics	***Aus***	3.30	.92	3.60	.81	5.1***
	USA	3.32	.90	3.60	.79	3.7**
8 Think they did not work hard enough if do not do well in mathematics	***Aus***	3.03	.98	3.40	.83	5.7***
	USA	3.38	.94	3.51	.83	1.7
9 Parents would be disappointed if they do not do well in mathematics	***Aus***	2.95	.87	3.16	.70	3.8***
	USA	3.04	.87	3.18	.78	1.9
10 Need mathematics to maximise future employment opportunities	***Aus***	2.81	.82	3.05	.66	4.7***
	USA	2.81	.76	2.99	.72	2.8**
11 Like challenging mathematics problems	***Aus***	3.01	.95	2.98	.92	0.5
	USA	2.98	1.02	2.81	.84	2.1*
12 Are encouraged to do well by the mathematics teacher	***Aus***	3.00	.85	3.02	.62	0.5
	USA	3.07	.74	3.02	.62	0.72
13 Mathematics teachers thinks they will do well	***Aus***	3.28	.87	3.24	.67	0.6
	USA	3.08	.88	3.08	.62	0.0
14 Think mathematics will be important in their adult life	***Aus***	2.99	.86	3.24	.71	4.7***
	USA	2.96	.88	3.06	.7	1.3
15 Expect to do well in mathematics	***Aus***	3.14	1.01	3.29	.80	2.4*
	USA	3.09	1.00	3.14	.82	0.6
16 Distract other students from their mathematics work	***Aus***	2.15	1.16	2.15	.97	0.0
	USA	2.59	1.22	2.04	.96	5.8**
17 Get the wrong answers in mathematics	***Aus***	2.68	.88	2.81	.65	2.3*
	USA	2.85	.91	2.93	.6	1.1
18 Find mathematics easy	***Aus***	3.16	.98	3.12	.71	0.7
	USA	3.00	.95	2.96	.75	0.6
19 Parents think it is important for them to study mathematics	***Aus***	2.94	.79	3.09	.52	3.3***
	USA	2.89	.75	3.02	.52	2.4*
20 Need more help in mathematics	***Aus***	2.51	.91	2.84	.71	5.9***
	USA	2.86	.95	2.94	.76	1.1
21 Tease boys if they are good at mathematics	***Aus***	2.68	1.13	2.65	.95	0.5
	USA	2.84	.97	2.80	.87	0.5
22 Worry if they do not do well in mathematics	***Aus***	3.28	.98	3.57	.81	4.6***
	USA	3.33	.96	3.59	.84	3.2**

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Item #		Males Mean	Males SD	Females Mean	Females SD	t (sig. level)
23 Are not good at mathematics	**Aus**	2.79	.83	2.94	.61	2.9**
	USA	2.87	.93	2.95	.57	1.2
24 Like using computers to work on mathematics problems	**Aus**	2.63	.98	2.66	.85	0.5
	USA	2.65	.95	2.65	.70	0.0
25 Mathematics teachers spend more time with them	**Aus**	3.05	1.04	2.96	.72	1.47
	USA	3.17	.85	3.07	.70	1.5
26 Consider mathematics to be boring	**Aus**	2.27	1.00	2.75	.97	7.0***
	USA	2.46	.98	2.84	.85	4.8**
27 Find mathematics difficult	**Aus**	2.62	.83	2.87	.70	4.7***
	USA	2.80	.90	3.01	.71	3.0**
28 Get on with their work in class	**Aus**	3.57	.98	3.42	.82	1.5
	USA	3.40	.94	3.42	.74	0.4
29 Think mathematics is interesting	**Aus**	3.12	.93	3.04	.67	2.6*
	USA	3.11	.93	3.04	.69	0.9
30 Tease girls if they are good at mathematics	**Aus**	2.77	1.06	2.51	.89	3.9***
	USA	2.69	.93	2.61	.82	1.1

Note. The score for each subscale ranges from 1 to 5. Means > 3 indicate that "boys are more likely than girls" to have the trait described and means < 3 indicate the opposite.
Shaded regions: items for which statistically significant differences were found.
Levels of statistical significance of t: * p<.05 ** p<.01 ***p<.001

The shading on Table 4 assists in identifying the similarities and differences in the findings with respect to significant gender differences in the two countries:

- For nine items (1, 6, 12, 13, 18, 21, 24, 25, & 28) there were no gender differences in the responses of students in both countries (unshaded items)
- Overall there were more statistically significant gender differences found among the Australian students than among the USA students. The different sample sizes may have partially contributed to this finding.
  - For eight items (2, 5, 7, 10, 19, 22, 26, 27), gender differences were found for both the Australian and USA data. [item and findings for both countries are shaded]
  - Of the remaining 13 items for which gender differences were found in at least one country, there were 11 items (3, 4, 8, 9, 14, 15, 17, 20, 23, 29 & 30) with gender differences among the Australian students, and only two items (11 & 16) with gender differences among the USA students.

The mean scores for the entire samples of Australian and US secondary students are illustrated in Figure 3. The similarities and differences in the directions of the responses from the Australian and US students that can be seen in Figure 3 include:

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- For the vast majority of items (25), the direction of the responses of students in both countries were the same. Of these, the response directions for seven items (2, 10, 16, 21, 24, 28, & 30) were consistent with previous findings
- Independent groups t-tests revealed that there were statistically significant differences by country on 17 items (1, 3-5, 8, 11, 13, 14, 16-18, 20, 21, & 26-29) – see Table 5. In most of these cases, the differences were due to one group or the other having a more extreme belief in one direction For example, Australian students believed more strongly than the US students that boys were more likely than girls to "need more help in mathematics" (item 20) and girls were more likely than boys to "expect to do well in mathematics" (item 15).
- There were 5 items (3, 5, 11, 18 &19) for which there were differences in the direction of students' responses by country (four items – 3, 5, 11 & 18 – were found to be statistically significantly different). The direction of the US students' responses were consistent with previous findings on four of the five items (5, 11, 18 & 19) and the Australian students' responses only on item 3.

PLACE FIGURE 3 ABOUT HERE

Pre-service teachers

Sample and methods

The sample sizes of the pre-service teachers were:

Australia: 394 (66M, 327F, 1?) USA: 97 (11M, 85F, 1?)

The 30 items comprising the *Who and mathematics* instrument (see Table 3) were administered to the Australian and US pre-service teachers. Because of the wording of the items on the scale and the instructions to pre-service teachers to think about what happens in contemporary high school mathematics classrooms as they responded to items, comparisons between the students' and the pre-service teachers' responses reflect differences in students' beliefs and pre-service teachers' views of students' beliefs.

Comparisons between secondary students and pre-service teachers from Australia[7]

Of interest were the differences in the directions of the responses of the Australian secondary students and the pre-service teachers' beliefs about how today's high school students would view these issues. The differences in the response directions are clearly illustrated in Figure 4. For 13 items (2, 3, 4, 7, 8, 10, 11, 16, 21, 22, 24, 28 & 30), the pre-service teachers' views and the students' beliefs were consistent. Without exception, the direction of the pre-service teachers' responses on the remaining 17 items were the same as those predicted from previous research. In other words, the pre-service teachers appear to have expected students to have beliefs consistent with the stereotyping of mathematics as a "male domain". Consider Item 15 as a representative example. The secondary students believed that girls were more likely than boys to "expect to do well in mathematics"; the pre-service teachers believed that students would think that it was boys who were more likely to do so, the predicted response direction based on previous research (see Table 3).

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7 The data from the US students and pre-service teachers were also compared and are reported in Kloosterman et al. (2001).

PLACE FIGURE 4 ABOUT HERE

Comparisons between Australian and US pre-service teachers

Because of the small number of males in both the Australian and US pre-service teacher cohorts, it was deemed inappropriate to conduct analyses by gender.

Independent groups t-tests, by country, were conducted for each of the 30 items on the *Who and mathematics* instrument. The mean scores for all items, t-values and significance levels for items with statistically significant differences in their means are shown in Table 5. The data are illustrated graphically in Figure 5.

PLACE FIGURE 5 ABOUT HERE

As is evident from Figure 5 (and Table 5), the *directions* of the beliefs of the pre-service teachers from the two countries were the same for all items except Item 4. The means for Item 4 reveal that the Australians believed that high school students would consider that there was no difference between girls' and boys' likelihood to "give up when they find a mathematics problem is too difficult"; the Americans, however, indicated that they believed high school students were likely to consider that girls were more likely than boys to do so.

Table 5. Mean scores by country and significance levels of independent groups t-tests

Item No.	Australia	USA	t (sig. level)	Item No.	Australia	USA	t (sig. level)
1	2.68	2.38	4.0***	16	2.18	2.31	1.5
2	3.07	3.02	0.7	17	3.02	3.14	2.2*
3	2.67	2.28	4.2***	18	2.76	2.47	4.0***
4	2.98	3.45	5.0***	19	2.76	2.86	1.4
5	3.14	3.33	2.6**	20	3.12	3.41	4.0***
6	2.76	2.54	2.8**	21	2.69	2.79	1.1
7	3.18	3.15	0.4	22	3.23	3.41	2.0*
8	3.33	3.43	1.0	23	3.1	3.29	3.2**
9	2.71	2.83	1.5	24	2.45	2.48	0.4
10	2.74	2.61	1.6	25	2.87	2.78	1.0
11	2.68	2.42	3.2**	26	3.11	3.35	3.0**
12	2.92	2.72	2.6*	27	3.23	3.43	3.1**
13	2.87	2.44	5.1***	28	3.59	3.26	4.5***
14	2.72	2.58	1.7	29	2.84	2.55	4.5***
15	2.73	2.6	1.4	30	2.64	2.58	0.7

Levels of statistical significance of t: * p<.05 ** p<.01 ***p<.001

The directions of the pre-service teachers' responses were compared to the predictions from the research (see Leder, 2001 and Table 3). On average, the pre-service teachers in both countries believe that high school students are likely to hold views consistent with previous research findings. In other words, the pre-service teachers beliefs were that high school students still have traditionally stereotyped views of mathematics as a "male domain".

Summary of findings

Mathematics as a gendered domain

- On average, in both Australia and the USA, male and female secondary students, and pre-service teachers, generally agreed that mathematics was a neutral domain (mean scores > 3) and disagreed that mathematics was either a male or a female domain (mean scores < 3)

Among secondary students in both countries:

- the directions of the gender differences in the scoring patterns were the same
- the statistically significant gender differences found indicated that:
  - males believed more strongly that mathematics was a *male domain*
  - females believed more strongly that mathematics was a *neutral domain.*
- females believed more strongly that mathematics was a *female domain* – the difference was significant in the USA but not in Australia.

Among the pre-service teachers in both countries:

- there was no difference in the extent to which the pre-service teachers generally agreed that mathematics was a *neutral domain* and disagreed that it was a *male domain*
- US pre-service teachers disagreed significantly more strongly than the Australians that mathematics was a *female domain.*

Who and mathematics

Among secondary students in both countries:

- the scoring directions on most of the 30 items were inconsistent with directions based on previous research in the field.
- Several of the items to which response directions were in line with earlier research findings appeared related to classroom behaviors. For example, boys were perceived as the teasers of successful students and as the distractors of others from their work; girls were seen as getting on with their work in class.
- the items for which statistically significant gender differences were found tended to show that either male or female respondents held a more extreme view of whether it was boys or girls who were more likely to conform to the wording of the particular items.

A general observation was that the extent of the change of direction of beliefs appeared slightly stronger among the Australian secondary students.

Among the pre-service teachers in both countries, beliefs based on their views of contemporary high school mathematics classroom indicated that:

- response directions were generally consistent with those predicted from earlier research
- there was a stark contrast in the response directions of the pre-service teachers and of the secondary students

Final words

Data from the *Mathematics as a gendered domain* instrument revealed that mathematics is generally regarded as a neutral domain and there is broad disagreement that is it either a male or a female domain. The findings from the *Who and mathematics* instrument indicated a change in the gendering of aspects related to the learning of mathematics among secondary students in both countries. The apparent shift in beliefs was not apparent among the pre-service teachers based on their perceptions of contemporary high schools mathematics classrooms. That the changes in beliefs were observed using both scales is powerful evidence that the findings were not artifacts of one particular item response format.

The consistency in the patterns of change among the secondary students in both countries may be partially attributable to the similarities in the mainstream cultural and social dimensions in Australia and the USA and to the comparable efforts made to redress previously identified inequities that had disadvantaged females in mathematics learning outcomes.

That the pre-service teachers' views were inconsistent with the high school students' beliefs may indicate that they were, in effect, reflecting on their own high school experiences in mathematics classrooms rather than having a real appreciation for what students perceive happening in their classrooms today. If this is the case, the age gap between the students and the pre-service teachers would put the change that appears to have occurred among the school students to have taken place within the last decade. It would appear from the findings that some things have not changed, particularly with regards to the classroom behaviors of males.

Implications for further research

The findings from this study invite further exploration. The instruments need to be administered more widely among high school students and pre-service teachers and the findings should be compared to those reported here.

A qualitative exploration may uncover why apparent changes have emerged in the secondary students' but not the pre-service teachers' beliefs about the gender-stereotyping of mathematics. It would be important to try to pinpoint factors that have contributed to the changing pattern of beliefs and to determine more precisely how the transition took place and where it has occurred.

There is increasing research evidence of the interacting effects of gender, ethnic/race-related and socio-economic background factors on mathematics learning outcomes. These variables should be included in the research designs of projects in which these and other instruments are used to measure mathematics-related beliefs. It would also be of value to gather data from students and pre-service teachers in other countries around the world.

Constant monitoring of affective dimensions associated with the teaching and learning of mathematics is needed if equity remains a goal of mathematics education. When discussing any observed changes such as those discussed in this paper, it is also important to avoid the polarization of opinion that can result from media reports adopting 'gender wars' type headlines.

References

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Leder, G. C. (2001). Mathematics as a gendered domain: New measurement tools. Paper presented at the annual meeting of American Education Research Association [AERA], as part of the symposium *Mathematics: Still a male domain?* Seattle, USA, April 10-14.

Figure 2. *Who and mathematics*: Mean scores for Australian secondary (grade 7-10) students by gender

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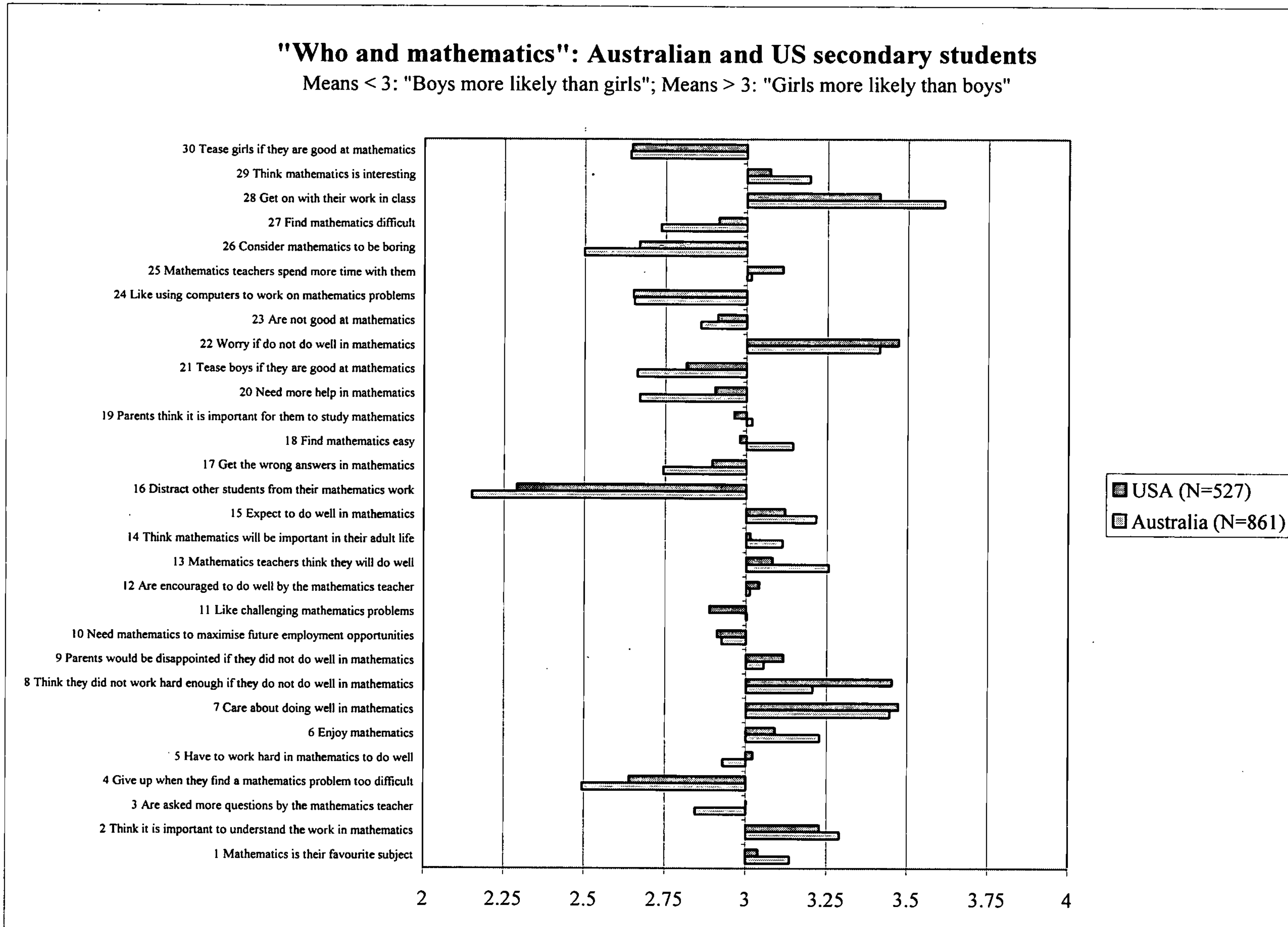

Figure 3. "Who & mathematics": Mean scores for secondary students in Australia (grades 7-10) and the USA (grades 7-12)

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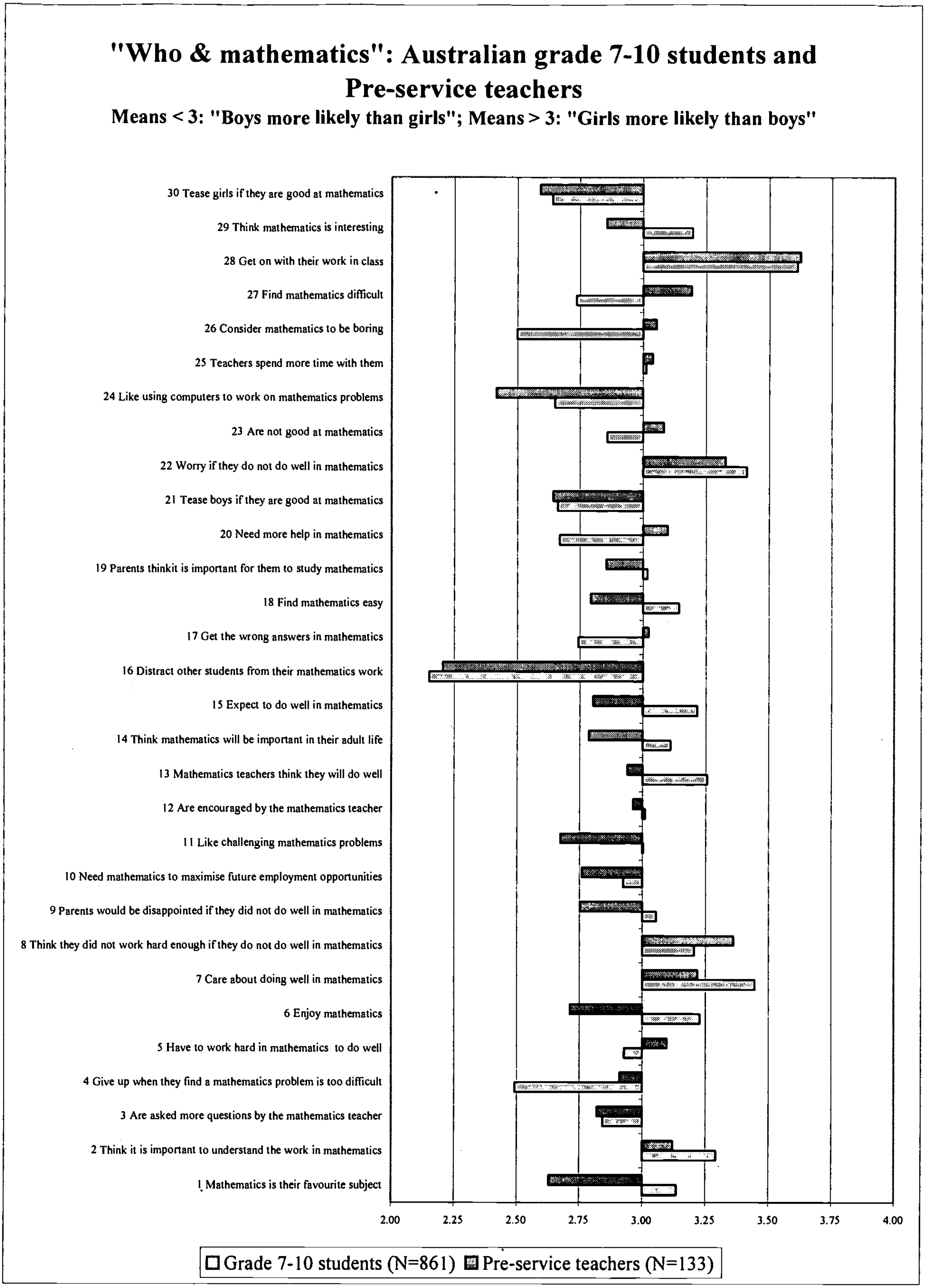

Figure 4. “Who & mathematics”: Mean scores for Australian secondary students (grade 7-10) and pre-service teachers

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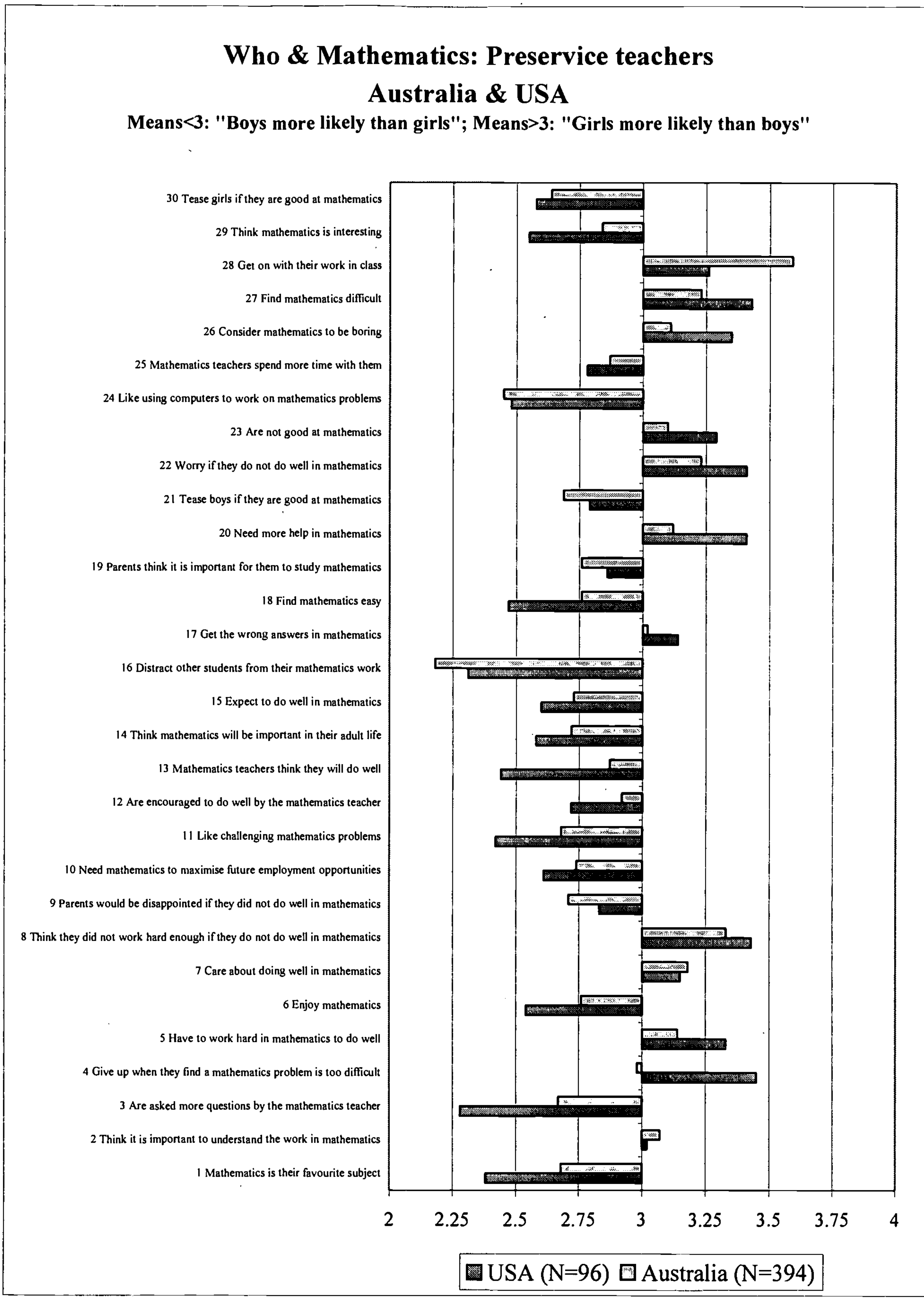

Figure 5. "Who & mathematics": Mean scores for Australian and US pre-service teachers

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