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ABSTRACT

Two forms of a new instrument, "Mathematics as a Gendered Domain" and "Who and Mathematics," were developed to replace one of the scales of the Fennema-Sherman Mathematics Attitudes Scales. The aim of both instruments is to measure the extent to which students stereotype mathematics as a gendered domain. For "Mathematics as a Gendered Domain," a Likert-type scoring format is used. The other instrument uses an innovative response format that asks students to indicate whether girls or boys are more likely to match the wording of the item. The instruments were developed with the cooperation of mathematics teachers and a dozen volunteer secondary school students. The developed scales were pilot tested with about 400 students in grades 7 through 10 in Australia, and modified versions were then administered to approximately 1,600 students in grades 7 through 10. Data show that a majority of students perceived mathematics as a gender-neutral domain, but among those who did not, girls were thought to be superior at mathematics. Boys' behaviors were thought to be less functional; boys were thought to be more likely to find mathematics difficult, to be bored, and to need more help. An appendix lists 13 articles related to the use of these instruments. (SLD)

Two New Instruments to Probe Attitudes About Gender and Mathematics

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Two new instruments to probe attitudes about gender and mathematics

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The instruments – a brief description

We developed two forms of a new instrument: *Mathematics as a gendered domain* and *Who and mathematics*, to replace one of the scales, the *Mathematics as a male domain* scale, of the widely used Fennema-Sherman [F-S] *Mathematics Attitudes Scales* [MAS]. We have argued elsewhere (Forgasz, Leder, & Gardner, 1999), and in some detail, the need for a revision of this scale. The final versions of our new instruments also cover aspects of other scales of the MAS[1].

The aim of both versions of the instrument is to measure the extent to which students stereotype mathematics as a gendered domain; that is, the extent to which they believe that mathematics may be more suited to males, to females, or be regarded as a gender-neutral domain. 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) guided the development of the items.

An important difference between the two versions of the instrument is in the response formats used. For the *Mathematics as a gendered domain* scale, a traditional Likert-type scoring format has been adopted – students are asked to indicate the extent to which they agree (or disagree) with each statement presented. A five-point scoring system is used – strongly disagree (SD) to strongly agree (SA). A score of 1 is assigned to the SD response and a score of 5 to SA. This version of the instrument consists of 48 items. There are three subscales: *Mathematics as a male domain, Mathematics as a female domain,* and *Mathematics as a neutral domain.* The 16 items making up each of the three subscales are shown in Table 1. The items are presented in a random order on the questionnaire (see appendix 2).

INSERT TABLE 1 ABOUT HERE

An innovative response format has been adopted for the *Who and mathematics* version of the instrument. For each statement, students are asked 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

1 The MAS consist of nine scales: confidence; effectance motivation, mathematics anxiety, usefulness of mathematics; attitude towards success; mathematics as a male domain [MD]; and father, mother and teacher scales.

This scale contains 30 statements. In order to interpret the response patterns to items more readily, the categories are scored as follows:

BD = 1, BP = 3, ND = 3, GP = 4 and GD = 5.

Mean scores can thus be calculated for each item. A mean score <3 indicates that, on average, the students believe that boys are more likely than girls to match the wording of the item; mean scores >3 that they believe girls to be more likely than boys to do so. One-sample t-tests can be used to determine if mean scores are significantly different from 3, the score that represents a belief that "there is no difference between boys and girls", and independent groups t-tests to explore for possible gender differences in the responses to each item.

Several additional (scorable) questions, probing students' perceptions about their proficiency in mathematics and their longer term study plans, are common to both versions of the instrument. Space has also been left at the end of both versions of the instrument for students to add any other comments they consider important or relevant.

Both versions of the instrument are shown in Appendix 2.

Development of the instruments

Stage 1

In Stage 1, we prepared items using the two types of response formats described above. In developing this first set of items, we drew on previous research findings about gender issues in mathematics learning, obtained feedback on the instrument from 10 volunteer mathematics educators and from 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.

Stage 2

The items remaining after stage 1 (above) were trialed in two parallel versions of the instrument. Each version contained items in both response formats. Approximately 400 students from grades 7-10 in schools across Victoria (Australia) completed each version of the instrument. In each school, and in each grade, half of the students completed one version, the other half filled out the parallel version.

The effectiveness of the different items and formats was examined statistically. Possible gender and grade level differences were also explored. Selected results from this trial have been summarized in Forgasz, Leder and Barkatsis (1998; 1999).

Stage 3

In preparation for the second trial, psychometrically unsatisfactory items were deleted from the two parallel versions of the instrument. Students' comments about some of the items were also taken into account in the culling process. Some new items were added to produce the second versions of the instrument. It was at this time that the parallel versions combining the two response formats were abandoned. The first trial (Stage 2 above) had revealed that the instrument was too long and time consuming to complete. In response, we devised two separate instruments, one in which only items with Likert type response formats were used (*Mathematics as a gendered domain)*; the other comprised items with the new response format described earlier (*Who and mathematics)*.

The newly modified versions of the instrument were administered to approximately 1600 grade 7-10 students from eight schools situated in the metropolitan and country regions of Victoria. Again, half of the students at each grade level in each school completed the *Mathematics as a gendered domain* instrument, and the other half filled out the *Who and* *mathematics* version. The results of these administrations are reported in the remainder of this paper.

Psychometric properties of the new instrument

The focus of this section is on the *Mathematics as a gendered domain* instrument. The format of this version is comparable to the Fennema- Sherman *Mathematics as a male domain* scale.

Factor analysis

A confirmatory factor analysis was conducted to check whether the *Mathematics as a gendered domain* scale consisted of the three distinct (orthogonal) subscales that had been hypothesized: i. *Mathematics as a male domain,* ii. *Mathematics as a female domain* and iii. *Mathematics as a neutral domain*. The results of the Varimax rotation are shown in Figure 1. Three clear factors comprising the items on each of the three subscales were identified.

INSERT FIGURE 1 ABOUT HERE

Reliability

A reliability analysis was conducted on the items comprising each subscale. For each subscale, item-total correlations confirmed the internal consistency of the items. Cronbach-alpha values for the three subscales were as follows:

Mathematics as a male domain [MD]: $\alpha = .902$

Mathematics as a female domain [FD]: $\alpha = .897$

Mathematics as a neutral domain [ND]: $\alpha = .836$

These values are similar to the split-half reliability of .87 reported by Fennema and Sherman (1976) for their *Mathematics as a male domain* scale.

Descriptive statistics

The mean score for each of the three subscales was calculated (range 16-80). These scores were divided by 16 (number of items per subscale) giving scores between 1 and 5 (values consistent with the Likert-scale scoring to assist in the interpretation of the findings). The subscale means and standard deviations are shown on Table 2. The data reveal that, in general, students did not gender-stereotype mathematics. Mean scores were >3 (indicating agreement) for perceptions of mathematics as a *neutral domain* and <3 (indicating disagreement) for perceptions of mathematics as both a *male domain* and a *female domain*. Of interest here is the finding that students believed slightly more strongly that mathematics was a *female domain* than a *male domain*.

INSERT TABLE 2 ABOUT HERE

Bivariate Pearson product-moment correlations were found for each combination of subscales. The results are shown on Table 3.

INSERT TABLE 3 ABOUT HERE

The statistically significant and moderately valued negative correlation between the ND and the MD subscales (-.367) is consistent with beliefs that mathematics is either a neutral domain or a male domain. The statistically significant and moderately valued negative correlation between the ND and the FD subscales (-.367) is similarly explained. The statistically significant and moderately valued positive correlation between the MD and the FD subscales (.468) is more problematic. A scatter diagram for scores on both subscales (see Figure 2) reveals that the combination of low scores (<3) on both subscales – meaning general disagreement that mathematics is stereotyped as either a male or female domain – contributes substantially to this correlation value.

INSERT FIGURE 2 ABOUT HERE

Target group for instruments

The current versions of the instruments are aimed at high school students – the same population for whom the original Fennema-Sherman MAS were developed. However, with minor adaptations, the instruments can be (and have been) administered to other groups, e.g., pre-service teachers (see Forgasz, 2001a, 2001b). Administration of the instruments to samples of high school students in countries other than Australia have yielded findings in broad agreement with those reported below as well as indications of subtle cultural differences (see Barkatsas, Forgasz, & Leder, 2001[2]; Brandell, personal communications January 27, 2002[3]; Forgasz, Leder, & Kaur, 2001[4]; Kloosterman, Tassell, & Ponniah, 2001[5])

Results

The results described here are based on the data gathered from the administration of the two separate instruments, *Mathematics as a gendered domain* and *Who and mathematics.*

Mathematics as a gendered domain

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

The mean scores obtained on each of the three subscales – *Mathematics as a male domain, Mathematics as a female domain, and Mathematics as a neutral domain* – for all students, for males and for females separately, as well as the t-test results by gender, are shown in Table 4.

As can be seen from the data in Table 4, the 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 differences in males' and females' perceptions of mathematics as a *female domain.*

INSERT TABLE 4 ABOUT HERE

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2 Findings of a sample of students in Greek secondary schools are reported in this paper
3 Findings obtained for students in secondary schools in Sweden
4 Data are reported for Singaporean secondary school students
5 Data are reported for students at school in the US

Who and mathematics

Sample size: N = 861 (436M, 402F, 23?)[6] grade 7-10 students.

The frequency distributions of the responses to each item were examined closely. It was found that the most frequent response category in the vast majority of cases was ND – *no difference between boys and girls*. The high ND response rates indicate, as for the responses on the *Mathematics as a gendered domain* scale, that most students did not gender-stereotype those aspects of mathematics tapped in the wording of the majority of the items on this version of the instrument. However, subtle differences in response patterns were observed among students who did not use the ND category. It is these students who, it is argued, hold gender stereotyped beliefs about some aspects of mathematics learning.

Consider the frequency distribution for students' responses to Item 20, *Need more help in mathematics*, shown in Figure 3. The most frequent response was ND. However, it is clear that there were more BP and BD responses in total than GP and GD responses. In other words, overall, more students believed that 'boys were more likely than girls' *to need more help in mathematics*.

Using the scoring method described earlier, mean scores were calculated for each item as well as separately for the males and the females. One-sample t-tests were conducted on the mean scores to test for statistically significant differences, at the $p<.05$ level, from 3, the score of the ND response.

INSERT FIGURE 3 ABOUT HERE

For items with mean scores that were statistically significantly different from 3:

- mean scores <3 meant that, on average, respondents believed that boys were more likely than girls to match the wording of the items (e.g., mean score for Item 20 – see Figure 1, was 2.67), and
- mean scores >3 that they believed girls were more likely than boys to do so.

For items with mean scores that were not significantly different from 3, respondents, on average, considered that there was *no difference* between girls and boys with respect to the wording associated with the item.

Findings from earlier research in the field – the basis upon which the items were developed – enabled us to predict the directions of responses for each of the 30 items comprising the instrument (shown in Table 5). There are some items for which the related research findings have been mixed – these are indicated in Table 5 using M/F.

In addition to the 30 items, the mean score for each item for the sample of grade 7-10 students and the direction it represents are also shown in Table 5. The response directions reflect students' beliefs as follows:

M = "boys more likely than girls" to behave or hold belief consistent with item wording (mean<3)

F = "girls more likely than boys" to behave or hold belief consistent with item wording (mean>3)

[6] 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

nd = "no difference between girls and boys" with respect to item wording (item mean not significantly different from 3)

Items with response directions as predicted by earlier research are shaded in Table 5.

INSERT TABLE 5 ABOUT HERE

The data in Table 5 provide evidence of a changing belief system, at least as far as Australian grade 7-10 students are concerned. It can be seen that the responses of our sample were consistent with predictions based on previous research for only eight items (2, 3, 10, 16, 21, 24, 28, and 30). Four of these items deal with issues associated with classroom behavior (16, 21, 28, 30) – boys are believed to tease both boys and girls who are good at mathematics and distract others from their work, while it is girls who get on with their work. Boys are considered more likely than girls to like using computers for mathematics problems and more likely to need mathematics to maximize employment opportunities. Students believe girls are more likely than boys to think it important to understand the work. Teachers, they believe, ask boys more questions than they ask girls.

The findings described above suggest that students now believe that it is girls rather than boys who are more capable mathematically, enjoy mathematics, find it interesting and challenging, and whom teachers expect to succeed. The students now consider boys more likely than girls to be bored by mathematics, have to work hard to do well, give up when things get difficult, find mathematics difficult, and to need more help. Students believe that parents no longer favor their sons with respect to who they believe need mathematics, and who would disappoint them if they did not do well. These views are in stark contrast to those reported in earlier work in this field.

Gender differences in responses

Independent groups t-tests were conducted on the 30 items to test for statistically significant gender differences in the students' responses. Mean scores and standard deviations for males and for females, and t-test results – t-values and levels of statistical significance – are shown in Table 6. One-sample t-tests were also conducted on the mean scores for males and for females and means that were not significantly different from 3 are indicated with a hash (#).

INSERT TABLE 6 ABOUT HERE

For 22 of the 30 items, males and females were consistent in their beliefs about which group (boys or girls) was more likely to behave or hold the belief reflected in the item wording (see Table 5 and Figure 4). The graph in Figure 4 has been produced to illustrate the direction of students' responses and the strength of the beliefs held as reflected by the mean scores obtained. The vertical axis passes through 3. This score for an item would indicate a belief that there is 'no difference between girls and boys'. Bars to the right of the vertical axis illustrate mean scores >3 (i.e. beliefs that 'girls are more likely than boys to…') and bars to the left mean scores <3. The strength of beliefs is clearly revealed by the length of the bars, that is how far they deviate from the mean score of 3 ('no difference between girls and boys').

INSERT FIGURE 4 ABOUT HERE

Of the 19 items (3, 4, 5, 7, 8, 9, 10, 14, 15, 17, 19, 20, 22, 23, 26, 27, 29 and 30) with statistically significant gender differences in the mean scores, most were due to either the males or the females having a stronger belief that either 'boys were more likely than girls' or 'girls were more likely than boys' to match item wording. Consider Item 2. Females believed more strongly than males that girls 'think it is important to understand the work in mathematics' ($p<.001$). For Item 4, males believed more strongly than females that boys 'give up when they find a mathematics problem is too difficult' ($p<.01$). There was no consistent pattern of either males or females holding stronger beliefs, however. There was only one item with a significant gender difference for which the male and female students' beliefs were in the directions supporting their own sex: females believed it was girls and males that it was boys who 'have to work hard to do well in mathematics' (Item 5, $p<.001$). There were, however, several significant gender differences on items for which one group's beliefs were in the direction of either girls or boys while the other group considered there was 'no difference between boys and girls'. For example, males believed that boys 'need mathematics to maximize future employment opportunities' but females believed that there was no difference between girls and boys (Item 10, $p<.001$). Females, on the other hand believed that girls were more likely than boys to 'think they did not work hard enough if they did not do well in mathematics' but males considered that there was no difference between boys and girls (Item 8, $p<.001$).

Concluding comments

In this paper we have described psychometric properties of two new instruments, designed to tap gender stereotypes about mathematics and the learning of mathematics. Findings obtained when these instruments were administered to high school students in a large state in Australia are also reported. The content and range of items included in the instruments were guided by previous research findings about gender issues in mathematics learning as well as the content of earlier scales.

Like many other developed countries, over the past two decades Australia has implemented a number of strategies aimed at achieving gender equity. In the development of the new instruments we thus took account of research findings that have been reported during the past 25 years since the design of earlier instruments such as the widely used Fennema-Sherman [F-S] *Mathematics Attitudes Scales* [MAS] as well as possible changes in societal norms with respect to gender role expectations. In particular, we did not assume that a "mathematics is NOT a neutral domain" response necessarily implied a belief that mathematics was a male domain, an assumption that underpinned the original Fennema-Sherman *Mathematics as a male domain* scale. Instead we allowed for the possibility that those who responded in this way may perceive mathematics as a female domain.

Our data revealed that on both surveys a majority of respondents perceived mathematics as a gender neutral domain, a finding also reported in earlier research. However, among those who did not regard mathematics as a neutral domain, girls rather than boys were thought to be superior at mathematics - for example, to be more capable, to enjoy it more, and, apparently thought by their teachers, to be more likely to succeed. Boys' behaviors were perceived as less functional – for instance, boys were perceived as more likely than girls to find mathematics difficult, to be bored by the subject, and to need more help. These views differ markedly from those reported in earlier work in this field.

We consider it significant that these broad findings were obtained on both instruments and thus do not appear to be a function of response format. Furthermore, although not reported in detail in this paper, administration of the surveys in different countries, including Singapore, Sweden, Greece and the USA, yielded findings which broadly mirrored those reported in this paper, although some cultural differences were discernible. Thus the instruments seem effective measures of current beliefs about the gender-stereotyping of mathematics and about learners of mathematics in different contexts. The data reported here from Australia seem to challenge past assumptions that females are disadvantaged with respect to mathematics learning and illustrate that students' beliefs about mathematics and themselves as learners of mathematics may be influenced by, and reflect, prevailing societal norms.

Table 1. The 48 items of the *Mathematics as a gendered domain scale* by subscale – MD, FD, and ND, the item numbers (Qn) on the questionnaire (see appendix 2) and the hypothesized dimensions (Dim) derived from the literature.

Qn	ITEM	Dim
	MD scale: 16 items	
16	Boys understand mathematics better than girls do	Abil
5	Mathematics is easier for men than it is for women	Abil
33	Men are mathematically more intelligent than women	Abil
27	Career choices make the study of mathematics more important for boys than for girls	Car
12	Boys have more use for mathematics than girls do when they leave school	Car
23	Mathematics is liked more by boys than by girls	GenAt
22	More boys than girls care about doing well at mathematics	GenAt
48	Girls are less interested in mathematics than are boys	GenAt
34	Boys are encouraged more than girls to do well in mathematics	Env
20	Boys, more than girls, want to do well in mathematics to please their parents	Env
37	There are more popular boys than popular girls who are good at mathematics	Peer
26	It is more acceptable for a man than a women to be good at mathematics	Peer
10	Boys are more determined than girls to do well in mathematics	Eff
21	Compared to boys, girls do less work in mathematics classes	Eff
29	Boys, more than girls, like challenging mathematics problems	Task
46	The mathematical tasks done in class suit boys more than they suit girls	Task
	FD scale: 16 items	
43	Girls are more likely than boys to believe they are good at mathematics	Abil
7	Girls have more natural mathematical ability than do boys	Abil
24	The weakest mathematics students are more often boys than girls	Abil
40	When they leave school, girls will have more use for mathematics than boys will	Car
6	Girls are more suited than boys to a career in a mathematically-related area	Car
41	Girls, more than boys, care about doing well at mathematics	GenAt
17	Girls enjoy mathematics more than boys do	GenAt
44	Girls are more likely than boys to say mathematics is their favourite subject	GenAt
36	Girls are encouraged more than boys to do well in mathematics	Env
32	In a mathematics class with both boys and girls, girls tend to speak up more than boys	Env
13	Parents believe mathematics is more important for their daughters than for their sons	Env
18	Boys are distracted from their work in mathematics classes more than are girls	Peer
39	Girls are more careful than boys when doing mathematics	Eff
28	Compared to girls, boys give up more easily when they have difficulty with a mathematics problem	Eff
35	Boys, more than girls, say the mathematics test was too hard if they do not do well	Task
14	Explaining answers in mathematics is harder for boys than for girls	Task
	ND scale: 16 items	
1	Women and men are equally likely to be good mathematics teachers	Abil
4	Being good at mathematics comes as naturally to girls as to boys	Abil
30	Men and women are equally suited to careers in the computer industry	Car
8	It is just as difficult for girls as it is for boys to get a job in a mathematically-related profession	Car
31	Girls and boys are equally likely to believe that mathematics is important for their career	Car
9	Boys are just as likely as girls to enjoy mathematics	GenAt
47	Girls are just as likely as boys to say they want to excel in mathematics	GenAt
25	Students who say mathematics is their favourite subject are equally likely to be girls or boys	GenAt
19	Parents are as likely to help their daughters as their sons with mathematics	Env
3	Parents think that getting high grades in mathematics is as important for their daughters as for their sons	Env
11	Girls and boys who do well in a mathematics test are just as likely to be congratulated	Peer
42	Boys are just as likely as girls to help friends with their mathematics	Peer
15	Girls and boys are just as likely to be lazy in mathematics classes	Eff
38	Girls are just as likely to work hard in mathematics as boys	Eff
2	Students who get poor marks on mathematics tests are just as likely to be boys as girls	Task
45	Boys and girls are equally good at using calculators in mathematics	Task

Key to dimensions of items on subscales:

Abil	Ability	GenAt	General attitude	Peer	Peers	Task	Task
Car	Career-related	Env	Environment	Eff	Effort		

Table 2: Subscale means and standard deviations

Subscale	N	Mean[a]	SD
MD	736	2.33	.670
FD	750	2.70	.697
ND	738	3.84	.556

[a] A score of 1 indicates strong disagreement and 5 indicates strong agreement.

Table 3: Bivariate Pearson product-moment correlations

	FD	ND
MD	.468**	-.367**
FD		-.367**

* p<.05 ** p<.01

Table 4. Means, standard deviations and independent group t-test results by gender for each subscale of *Mathematics as a gendered domain*

	ALL		MALES		FEMALES		
SUBSCALE[a]	Mean	SD	Mean	SD	Mean	SD	t (sig.level)[b]
MD	2.33	.670	2.54	.68	2.12	.59	9.0***
FD	2.70	.697	2.71	.72	2.69	.68	.28
ND	3.84	.556	3.76	.56	3.92	.54	3.8***

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

[b] Levels of statistical significance for t: * p<.05 ** p<.01 ***p<.001

Table 5. Predictions from previous research (Pred) and findings from Australian grade 7-10 students (Findings)

	ITEM	Pred	Findings			ITEM	Pred	Findings	
			Mean	Dir'n				Mean	Dir'n
1	Mathematics is their favorite subject	M	3.14	F	16	Distract other students from their mathematics work	M	2.15	M
2	Think it is important to understand the work in mathematics	F	3.29	F	17	Get the wrong answers in mathematics	F	2.74	M
3	Are asked more questions by the mathematics teacher	M	2.84	M	18	Find mathematics easy	M	3.14	F
4	Give up when they find a mathematics problem is too difficult	F	2.49	M	19	Parents think it is important for them to study mathematics	M	3.02	nd
5	Have to work hard in mathematics to do well	F	2.93	M	20	Need more help in mathematics	F	2.67	M
6	Enjoy mathematics	M	3.23	F	21	Tease boys if they are good at mathematics	M	2.66	M
7	Care about doing well in mathematics	M/F	3.45	F	22	Worry if they do not do well in mathematics	M/F	3.41	F
8	Think they did not work hard enough if do not do well in mathematics	M	3.21	F	23	Are not good at mathematics	F	2.86	M
9	Parents would be disappointed if they do not do well in mathematics	M	3.05	F	24	Like using computers to work on mathematics problems	M	2.65	M
10	Need mathematics to maximize future employment opportunities	M	2.93	M	25	Mathematics teachers spend more time with them	M	3.01	nd
11	Like challenging mathematics problems	M	3.00	nd	26	Consider mathematics to be boring	F	2.50	M
12	Are encouraged to do well by the mathematics teacher	M	3.01	nd	27	Find mathematics difficult	F	2.74	M
13	Mathematics teachers thinks they will do well	M	3.26	F	28	Get on with their work in class	F	3.61	F
14	Think mathematics will be important in their adult life	M	3.11	F	29	Think mathematics is interesting	M	3.20	F
15	Expect to do well in mathematics	M	3.22	F	30	Tease girls if they are good at mathematics	M	2.64	M

NB. Shaded items: findings consistent with predictions from previous research

Table 6. Means, standard deviations, one-sample t-test results and independent groups t-test results by gender for the 30 items on the *Who and mathematics* instrument.

Item	Males		Females		
	Mean	SD	Mean	SD	*t, sig. level*
1 Mathematics is their favorite subject	3.16	.75	3.09	.64	1.4
2 Think it is important to understand the work in mathematics	3.12	.77	3.47	.73	6.6***
3 Are asked more questions by the mathematics teacher	2.77	1.02	2.92#	.85	2.3*
4 Give up when they find a mathematics problem is too difficult	2.39	.99	2.59	.95	3.0**
5 Have to work hard in mathematics to do well	2.79	.88	3.08	.69	5.4***
6 Enjoy mathematics	3.27	.90	3.18	.64	1.7
7 Care about doing well in mathematics	3.30	.92	3.60	.81	5.1***
8 Think they did not work hard enough if do not do well in mathematics	3.03#	.98	3.40	.83	5.7***
9 Parents would be disappointed if they do not do well in mathematics	2.95#	.87	3.16	.70	3.8***
10 Need mathematics to maximize future employment opportunities	2.81	.82	3.05#	.66	4.7***
11 Like challenging mathematics problems	3.01#	.95	2.98#	.92	0.5
12 Are encouraged to do well by the mathematics teacher	3.00#	.85	3.02#	.62	0.5
13 Mathematics teachers thinks they will do well	3.28	.87	3.24	.67	0.6
14 Think mathematics will be important in their adult life	2.99#	.86	3.24	.71	4.7***
15 Expect to do well in mathematics	3.14	1.01	3.29	.80	2.4*
16 Distract other students from their mathematics work	2.15	1.16	2.15	.97	0.0
17 Get the wrong answers in mathematics	2.68	.88	2.81	.65	2.3*
18 Find mathematics easy	3.16	.98	3.12	.71	0.7
19 Parents think it is important for them to study mathematics	2.94#	.79	3.09	.52	3.3***
20 Need more help in mathematics	2.51	.91	2.84	.71	5.9***
21 Tease boys if they are good at mathematics	2.68	1.13	2.65	.95	0.5
22 Worry if they do not do well in mathematics	3.28	.98	3.57	.81	4.6***
23 Are not good at mathematics	2.79	.83	2.94	.61	2.9**
24 Like using computers to work on mathematics problems	2.63	.98	2.66	.85	0.5
25 Mathematics teachers spend more time with them	3.05#	1.04	2.96#	.72	1.47
26 Consider mathematics to be boring	2.27	1.00	2.75	.97	7.0***
27 Find mathematics difficult	2.62	.83	2.87	.70	4.7***
28 Get on with their work in class	3.57	.98	3.42	.82	1.5
29 Think mathematics is interesting	3.12	.93	3.04	.67	2.6*
30 Tease girls if they are good at mathematics	2.77	1.06	2.51	.89	3.9***

Note. Shaded regions: items for which statistically significant gender differences were found.
Levels of statistical significance of independent groups t-values: * p<.05 ** p<.01 ***p<.001
Asterisks: mean scores not significantly different from 3 (one sample t-tests results)

Rotated Component Matrix[a]

	Component		
	1	2	3
MDAbil1	.729		
MDAbil3	.700		
MDGenAt2	.700		
MDEff1	.654		
MDGenAt1	.646		
MDEff2	.646		
MDCar1	.635		
MDTask1	.623		
MDPeer2	.620		
MDTask2	.611		
MDAbil2	.585		
MDCar2	.583		
MDGenAt3	.556		
MDEnv2	.550		
MDEnv1	.518		
MDPeer1	.490		
FDEff1		.746	
FDAbil3		.734	
FDGenAt1		.734	
FDAbil1		.688	
FDEff2		.658	
FDTask2		.622	
FDTask1		.612	
FDGenAt3		.607	
FDGenAt2	.309	.598	
FDAbil2		.597	
FDCar1		.567	
FDPeer1		.543	
FDCar2		.533	
FDEnv1	.326	.502	
FDEnv2		.394	
FDEnv3		.385	
NDGenAt2			.611
NDCar3			.600
NDGenAt3			.597
NDEnv2			.593
NDEff2			.582
NDGenAt1			.546
NDPeer2			.534
NDEnv1			.516
NDCar1	-.308		.492
NDTask2			.491
NDCar2			.489
NDAbil2			.482
NDTask1			.455
NDPeer1			.450
NDAbil1			.389
NDEff1			.380

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 5 iterations.

Figure 1. ***Mathematics as a gendered domain*** **items. Factor analysis: Varimax rotation (See Table 1 for item name abbreviations)**

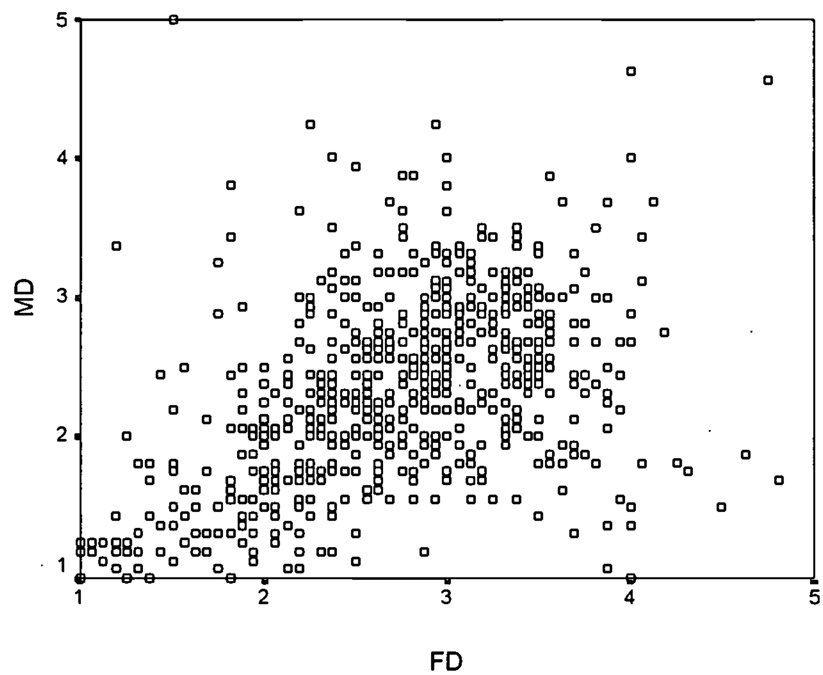

Figure 2: Scattergram for *Mathematics as a male domain* [MD] and *Mathematics as a female domain* [FD] scores

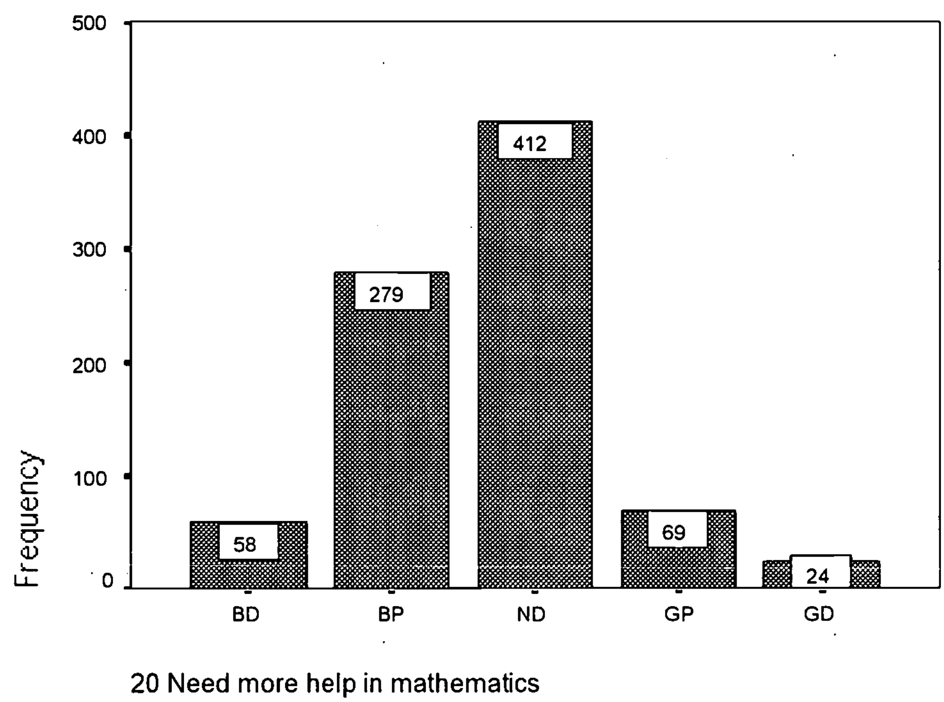

Figure 3. Frequency distribution for students' responses to Item 20 [*Who and mathematics instrument].*

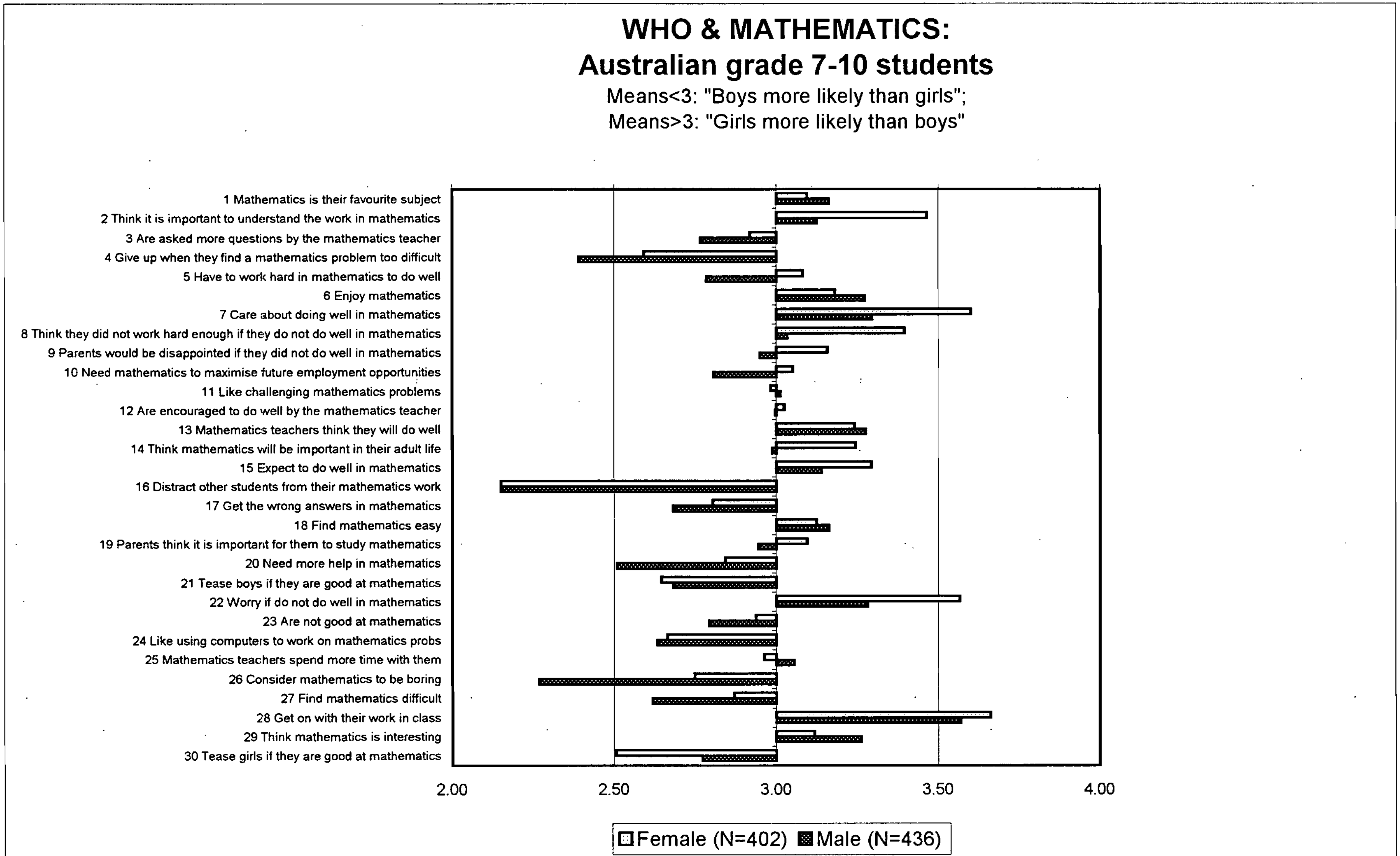

Figure 4. Mean scores for males and females for the 30 items of the *Who and mathematics* instrument

Appendix 1

Articles by the authors and other researchers using these instruments

Barkatsas, A., Forgasz, H., & Leder, G. (2001) The gender stereotyping of mathematics: Cultural dimensions. In J. Bobis, B. Perry, & M. Mitchelmore (Eds.) *Numeracy and Beyond.* Proceedings of the 24th annual conference of the Mathematics Education Research Group of Australasia, Inc. (Vol 1, pp. 74-81). Sydney: MERGA.

Forgasz, H. J. (2001a) *Mathematics as a gendered domain in Australia.* Paper presented at the annual meeting of AERA, as part of the symposium *Mathematics: Still a male domain?* Seattle, USA, April 10-14. [ERIC document: ED452071].

Forgasz, H. J. (2001b). Australian and US preservice teachers' perceptions of the gender stereotyping of mathematics. In M. van den Heuvel-Panhuizen (Ed.), *Proceedings of the 25th Conference of the International Group for the Psychology of Mathematics Education PME25@NL, Vol.2* (pp.2-433 – 2-440). Utrecht, The Netherlands: Freudenthal Institute. [July 12-17].

Forgasz, H. J., & Leder G. C. (2000). The 'mathematics as a gendered domain' scale. In T Nakahara & M Koyama (Eds.) *Proceedings of the 24th Conference of the International Group for the Psychology of Mathematics Education* (pp 2-273-2-279. Hiroshima: Department of Mathematics Education, Hiroshima University.

Forgasz, H. J., & Leder, G. C. (2001). "A+ for girls, B for boys: Changing perspectives on gender equity and mathematics. In B. Atweh, H. Forgasz, & B. Nebres (Eds). *Sociocultural research on mathematics education: An international perspective* (pp.347-366). Mahwah, NJ: Lawrence Erlbaum & Associates.

Forgasz, H. J., Leder, G. C., & Barkatsas, T. (1998) Mathematics - For boys? For girls? *Vinculum, 35*(3), 15-19.

Forgasz, H. J., Leder, G. C., & Barkatsas, T. (1999) Of course I can['t] do mathematics: Ethnicity and the stereotyping of mathematics. In J. M. Truran & K. M. Truran (Eds.). *Making the difference.* Adelaide: Mathematics Education Research Group of Australasia.

Forgasz, H. J., Leder, G. C., & Gardner, P. L. (1996). The Fennema-Sherman 'Mathematics as a male domain' scale: A re-examination. In L. Puig & A. Gutiérrez (Eds.), *Proceedings of the 20th Conference of the International Group for the Psychology of Mathematics Education, Vol.2*, (pp.2-361 - 2-368). Valencia, Spain: International Group for the Psychology of Mathematics Education.

Forgasz, H. J., Leder, G. C., & Gardner, P. L. (1999). The Fennema-Sherman 'Mathematics as a male domain' scale re-examined. *Journal for Research in Mathematics Education, 30*(3), 342-348.

Forgasz, H., Leder, G., & Kaur, B. (2001) Who can('t) do maths- boys/girls? Beliefs of Australian and Singaporean Secondary School . *Asia Pacific Journal of Education, 21*(2), 106-116.

Leder, G. C. (2001). *Mathematics as a gendered domain: New measurement tools.* Paper presented at the Annual Meeting of the American Educational Research Association, Seattle, Washington, April 10-14, 2001. Accepted for ERIC Clearinghouse on Assessment and Evaluation TM033048.

Leder, G. C., & Forgasz, H. J. (2000). Mathematics and gender: Beliefs they are a changin'. In J Bana & A Chapman (Eds.) *Mathematics education beyond 2000* (Proceedings of the

23rd Annual Conference of the Mathematics Education Research Group of Australasia Inc) (pp. 370-376). Perth, Western Australia: Executive Press.

Kloosterman, P., Tassell, J. H., & Ponniah, A. G. (2001) *Mathematics as a gendered domain in the United States*. Paper presented at the annual meeting of AERA, as part of the symposium *Mathematics: Still a male domain?* Seattle, USA, April 10-14.

Appendix 2

The two versions of the instrument. Spelling has been changed to conform with US conventions.

MATHEMATICS AS A GENDERED DOMAIN

The purpose of this survey is to find out your opinion about a number of statements related to boys' and girls' learning of mathematics. There are no correct or incorrect answers. We are only interested in your personal opinion.

The survey should take about 10-15 minutes to complete.

Please fill in the following information before answering the survey questions.

School ....

Please circle your responses to the following:

Gender: **Female / Male**

Grade Level: **7 / 8 / 9 / 10**

How good are you at mathematics? **Excellent / good/ average / below average / weak**

Do you plan to study mathematics in your last of year of secondary school? **Yes / No / Unsure**

At the end of the survey we have left a space for comments. We would value your feedback about any statements that you find confusing, unclear, contain words that you do not understand or are inappropriate in some other way. To make it easier for you, the statements have been numbered.

INSTRUCTIONS

Please circle ONE of the following responses to EACH statement as *quickly* as you can:

SA if you **STRONGLY AGREE** with the statement
A if you **AGREE** with the statement
NS if you are **NOT SURE** whether you agree or disagree with the statement
D if you **DISAGREE** with the statement
SD if you **STRONGLY DISAGREE** with the statement

If you change your mind about an answer, just cross it out and circle another one.

PRACTICE STATEMENT

0. Mathematics is a useful subject **SA A NS D SD**

If you disagree with this statement, you would circle the letter **D**

PLEASE TURN TO NEXT PAGE

1	Women and men are equally likely to be good mathematics teachers	SA	A	NS	D	SD
2	Students who get poor marks on mathematics tests are just as likely to be boys as girls	SA	A	NS	D	SD
3	Parents think that getting high grades in mathematics is as important for their daughters as for their sons	SA	A	NS	D	SD
4	Being good at mathematics comes as naturally to girls as to boys	SA	A	NS	D	SD
5	Mathematics is easier for men than it is for women	SA	A	NS	D	SD
6	Girls are more suited than boys to a career in a mathematically-related area	SA	A	NS	D	SD
7	Girls have more natural mathematical ability than do boys	SA	A	NS	D	SD
8	It is just as difficult for girls as it is for boys to get a job in a mathematically-related profession	SA	A	NS	D	SD
9	Boys are just as likely as girls to enjoy mathematics	SA	A	NS	D	SD
10	Boys are more determined than girls to do well in mathematics	SA	A	NS	D	SD
11	Girls and boys who do well in a mathematics test are just as likely to be congratulated	SA	A	NS	D	SD
12	Boys have more use for mathematics than girls do when they leave school	SA	A	NS	D	SD
13	Parents believe mathematics is more important for their daughters than for their sons	SA	A	NS	D	SD
14	Explaining answers in mathematics is harder for boys than for girls	SA	A	NS	D	SD
15	Girls and boys are just as likely to be lazy in mathematics classes	SA	A	NS	D	SD
16	Boys understand mathematics better than girls do	SA	A	NS	D	SD
17	Girls enjoy mathematics more than boys do	SA	A	NS	D	SD
18	Boys are distracted from their work in mathematics classes more than are girls	SA	A	NS	D	SD
19	Parents are as likely to help their daughters as their sons with mathematics	SA	A	NS	D	SD
20	Boys, more than girls, want to do well in mathematics to please their parents	SA	A	NS	D	SD
21	Compared to boys, girls do less work in mathematics classes	SA	A	NS	D	SD
22	More boys than girls care about doing well at mathematics	SA	A	NS	D	SD

23	Mathematics is liked more by boys than by girls	SA	A	NS	D	SD
24	The weakest mathematics students are more often boys than girls	SA	A	NS	D	SD
25	Students who say mathematics is their favorite subject are equally likely to be girls or boys	SA	A	NS	D	SD
26	It is more acceptable for a man than a women to be good at mathematics	SA	A	NS	D	SD
27	Career choices make the study of mathematics more important for boys than for girls	SA	A	NS	D	SD
28	Compared to girls, boys give up more easily when they have difficulties with a mathematics problem	SA	A	NS	D	SD
29	Boys, more than girls, like challenging mathematics problems	SA	A	NS	D	SD
30	Men and women are equally suited to careers in the computer industry	SA	A	NS	D	SD
31	Girls and boys are equally likely to believe that mathematics is important for their career	SA	A	NS	D	SD
32	In a mathematics class with both boys and girls, girls tend to speak up more than boys	SA	A	NS	D	SD
33	Men are mathematically more intelligent than women	SA	A	NS	D	SD
34	Boys are encouraged more than girls to do well in mathematics	SA	A	NS	D	SD
35	Boys, more than girls, say the mathematics test was too hard if they do not do well	SA	A	NS	D	SD
36	Girls are encouraged more than boys to do well in mathematics	SA	A	NS	D	SD
37	There are more popular boys than popular girls who are good at mathematics	SA	A	NS	D	SD
38	Girls are just as likely to work hard in mathematics as boys	SA	A	NS	D	SD
39	Girls are more careful than boys when doing mathematics	SA	A	NS	D	SD
40	When they leave school, girls will have more use for mathematics than boys will	SA	A	NS	D	SD
41	Girls, more than boys, care about doing well at mathematics	SA	A	NS	D	SD
42	Boys are just as likely as girls to help friends with their mathematics	SA	A	NS	D	SD
43	Girls are more likely than boys to believe they are good at mathematics	SA	A	NS	D	SD
44	Girls are more likely than boys to say mathematics is their favorite subject	SA	A	NS	D	SD

45	Boys and girls are equally good at using calculators in mathematics	**SA**	**A**	**NS**	**D**	**SD**
46	The mathematical tasks done in class suit boys more than they suit girls	**SA**	**A**	**NS**	**D**	**SD**
47	Girls are just as likely as boys to say they want to excel in mathematics	**SA**	**A**	**NS**	**D**	**SD**
48	Girls are less interested in mathematics than are boys	**SA**	**A**	**NS**	**D**	**SD**

Comments

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THANK YOU FOR TAKING PART IN THIS PROJECT

WHO AND MATHEMATICS

The purpose of this survey is to find out your opinion about a number of statements related to boys' and girls' learning of mathematics. There are no correct or incorrect answers. We are only interested in your personal opinion.

The survey should take about 10-15 minutes to complete.

Please fill in the following information before answering the survey questions.

School ....

Please circle your responses to the following:

Gender: **Female / Male**

Grade Level: **7 / 8 / 9 / 10**

How good are you at mathematics? **Excellent / good/ average / below average / weak**

Do you plan to study mathematics in your last of year of secondary school? **Yes / No / Unsure**

At the end of the survey we have left a space for comments. We would value your feedback about any statements that you find confusing, unclear, contain words that you do not understand or are inappropriate in some other way. To make it easier for you, the statements have been numbered.

INSTRUCTIONS

For *each* item, you are asked to circle **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

PRACTICE STATEMENT

0. Dislike mathematics **BD BP ND GP GD**

If you think that *boys are probably more likely than girls* to dislike mathematics, you would circle **BP**

PLEASE TURN TO NEXT PAGE

Answer each question as *quickly* as you can. If you change your mind about an answer, just cross it out and circle another one.

1	Mathematics is their favorite subject	**BD BP ND GP GD**
2	Think it is important to understand the work in mathematics	**BD BP ND GP GD**
3	Are asked more questions by the mathematics teacher	**BD BP ND GP GD**
4	Give up when they find a mathematics problem is too difficult	**BD BP ND GP GD**
5	Have to work hard in mathematics to do well	**BD BP ND GP GD**
6	Enjoy mathematics	**BD BP ND GP GD**
7	Care about doing well in mathematics	**BD BP ND GP GD**
8	Think they did not work hard enough if they do not do well in mathematics	**BD BP ND GP GD**
9	Parents would be disappointed if they did not do well in mathematics	**BD BP ND GP GD**
10	Need mathematics to maximize future employment opportunities	**BD BP ND GP GD**
11	Like challenging mathematics problems	**BD BP ND GP GD**
12	Are encouraged to do well by the mathematics teacher	**BD BP ND GP GD**
13	Mathematics teachers think they will do well	**BD BP ND GP GD**
14	Think mathematics will be important in their adult life	**BD BP ND GP GD**
15	Expect to do well in mathematics	**BD BP ND GP GD**
16	Distract other students from their mathematics work	**BD BP ND GP GD**
17	Get the wrong answers in mathematics	**BD BP ND GP GD**
18	Find mathematics easy	**BD BP ND GP GD**
19	Parents think it is important for them to study mathematics	**BD BP ND GP GD**
20	Need more help in mathematics	**BD BP ND GP GD**
21	Tease boys if they are good at mathematics	**BD BP ND GP GD**
22	Worry if they do not do well in mathematics	**BD BP ND GP GD**
23	Are not good at mathematics	**BD BP ND GP GD**
24	Like using computers to work on mathematics problems	**BD BP ND GP GD**

25	Mathematics teachers spend more time with them	**BD**	**BP**	**ND**	**GP**	**GD**
26	Consider mathematics to be boring	**BD**	**BP**	**ND**	**GP**	**GD**
27	Find mathematics difficult	**BD**	**BP**	**ND**	**GP**	**GD**
28	Get on with their work in class	**BD**	**BP**	**ND**	**GP**	**GD**
29	Think mathematics is interesting	**BD**	**BP**	**ND**	**GP**	**GD**
30	Tease girls if they are good at mathematics	**BD**	**BP**	**ND**	**GP**	**GD**

Comments?

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THANK YOU FOR TAKING PART IN THIS PROJECT

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