DOCUMENT RESUME

ED 455 247 TM 033 048

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TITLE	Mathematics as a Gendered Domain: New Measurement Tools.
PUB DATE	2001-04-00
NOTE	10p.; Paper presented at the Annual Meeting of the American Educational Research Association (Seattle, WA, April 10-14, 2001).
PUB TYPE	Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	Foreign Countries; *Gender Issues; *Mathematics; Mathematics Achievement; Secondary Education; *Secondary School Students; *Sex Differences; Stereotypes; Surveys; Test Construction
IDENTIFIERS	Australia (Victoria)

ABSTRACT

Two forms of a survey instrument were developed, "Mathematics as a Gendered Domain" and "Who and Mathematics." Both versions were intended to measure the extent to which students stereotype mathematics as a gendered domain. The Mathematics as a Gendered Domain score used a traditional Likert-type scoring format, but an innovative response format was adopted for the Who and Mathematics version in which students had to select responses related to the difference between boys and girls. In developing the initial items, previous research, feedback from 10 educators, and responses from about 24 junior high school and high school students were used. In the first trial, approximately 400 Australian secondary school students completed the questionnaires. Items were deleted to revise the forms for a second trial administered to approximately 1,600 students from 8 Australian schools. The focus of the report is on the second trial of the Mathematics as a Gendered Domain scale. The significant correlation between two of the subscales is consistent with beliefs that mathematics is either a neutral domain or a male domain. Additional studies with the same instruments will investigate the mathematics stereotypes further. (Contains 2 figures, 3 tables, and 12 references.) (SLD)

Mathematics as a Gendered Domain: New Measurement Tools

Gilah C. Leder

Paper presented at the
Annual Meeting of the American Educational Research Association
(Seattle, WA, April 10-14, 2001)

Mathematics as a gendered domain: New measurement tools[1]

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Abstract

In this paper, the first of three in the symposium "Mathematics: Still a male domain?", background information is presented on the development of a new scale to explore the concept of "Mathematics as a Male Domain", as originally introduced in the Fennema-Sherman Mathematics Attitudes Scales. Two instruments - the "Who and mathematics" and "the Mathematics as a gendered domain" scales, and the steps taken in their development, are described. The psychometric properties of the Mathematics as a gendered domain scale are presented in some detail.

Introduction

The Fennema-Sherman [F-S] *Mathematics Attitudes Scales* [MAS] (Fennema & Sherman, 1976) have been used extensively to measure attitudes towards mathematics. 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. These constructs are "hypothesized to be related to the learning of mathematics by all students and/or cognitive performance of females" (Fennema & Sherman, 1976, p.1).

According to Walberg and Haertel (1992), Fennema and Sherman's (1977) first reported study about the MAS is among the most cited articles in mainstream journals of educational psychology. Findings pertaining to the *Mathematics as a Male Domain* scale were reported as follows:

> Male responses differed significantly from female responses. While boys did not stereotype mathematics strongly as a male domain on this scale, they always stereotyped it more strongly than did females. (Fennema & Sherman, 1977, p.68)

A decade or so later, an extensive meta-analysis of mathematics education research studies concerned with affective variables and gender revealed that "mathematics as a male domain" was found to have the greatest gender difference (i.e., largest effect size) of the various factors considered (Hyde, Fennema, Ryan, Hopp & Frost, 1990). Gender differences in perceptions of mathematics as a male domain were shown to have declined during the 1980s, but were still evident in contemporary work. Thus the construct "mathematics as a male domain" continued to be seen as a critical variable in helping explain perceived disadvantage experienced by females in mathematics and related areas.

The Mathematics as a Male Domain [MD] scale

The MAS were published in 1976. The assumptions underpinning the development of the MD were noted by Fennema and Sherman (1976):

[1] Paper prepared for the Symposium *Mathematics: Still a Male Domain,* presented at the AERA Annual Meeting, Seattle, April 10-14

> The less a person stereotyped mathematics, the higher the score. This is done to fulfill the purpose of the scale development as it was assumed that the less a female stereotyped mathematics as a male domain, the more apt she would be to study and learn mathematics. (p. 7)

The corollary of this assumption is, presumably, that low-scoring females believe mathematics to be a male domain and might thus be less likely to study and learn mathematics. When the scale was developed, there was no apparent allowance for beliefs that mathematics might be considered a *female* domain. This approach was consistent with prevailing Western societal views of the 1970s, but, as we argued in earlier papers (Forgasz, Leder, & Gardner, 1996; 1999), such an assumption can no longer be supported today.

The MD is an example of a summated-ratings scale with each of its 12 items (six positively and six negatively worded) scored on a 5-point Likert-type scale. Criteria for evaluating the quality of such scales have been well-established in the psychometric literature (see, for example, Henerson, Morris, & Fitz-Gibbon, 1978; Loewenthal, 1996). The description of the development of the MAS (Fennema & Sherman, 1976) indicates that sound consideration was given to these criteria.

However, as discussed in Forgasz, Leder, and Gardner (1999), if the criteria were applied today some of the items on the MD might well be rejected. More specifically, data from some of our earlier studies revealed that some respondents now consider females to be good at mathematics and more prepared to work hard at it. In the past, such responses have been applied to males and have been used as indicators of mathematics being perceived as a male domain. Hence, it could be argued, those who use these descriptors for females may perceive mathematics to be a *female* domain. Other responses revealed an awareness of societal and classroom factors that constrained females' mathematical attainments in the past and, in some cases, persist today. Some explanations revealed traditionally stereotyped expectations (e.g., men are smarter, females have to work hard to succeed), while others reversed these patterns. Other comments, particularly from adult respondents, revealed a reluctance to accept without qualification the generalizations inherent in some of the MD scale items. Collectively these issues highlight the need to re-examine item wording of the MD to ensure contemporary relevance.

Comparable arguments do not appear to apply to the items on the other eight MAS scales for which the underlying assumptions surrounding the meanings of the constructs have not undergone fundamental change over time.

A new instrument

We developed two forms of a new survey instrument: *Mathematics as a gendered domain* and *Who and mathematics*, in an attempt to address the criticisms of the original Fennema-Sherman MD subscale. The aim of both versions of the instrument was 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 was 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 on the questionnaire.

An innovative response format was adopted for the *Who and mathematics* version of the instrument. 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

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

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

Mean scores were calculated for each item. Thus, a mean score <3 meant that, on average, the students believed that boys were more likely than girls to match the wording of the item; mean scores >3 that they believed girls were more likely than boys to do so. Independent groups t-tests, by gender, were used to explore for gender differences in the responses to each item. These data are reported in Forgasz (2001).

Several open ended questions, probing students' perceptions about their proficiency in mathematics and their longer term study plans, were common to both versions. Space was also left at the end of both versions of the questionnaire for students to add any other comments they considered important or relevant.

Development of the instruments

Stage 1

In developing the first set of items, we drew on previous research findings about gender issues in mathematics learning, 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.

Stage 2

In the first trial, approximately 400 Year 7-10 students from Victorian schools completed the questionnaires. 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 summarised in Forgasz, Leder and Barkatsis (1998; 1999).

Stage 3

In preparation for the second trial, psychometrically unsatisfactory items were deleted from the original questionnaires and others added to produce the second version of the instruments. These modified questionnaires were administered to approximately 1600 students from eight schools situated in the metropolitan and country regions of Victoria.

Psychometric properties of the new instrument

The focus of this section is on the *Mathematics as a gendered domain* scale, whose format is comparable to the Fennema- Sherman MD subscale.

Factor analysis

A confirmatory factor analysis was conducted to check whether the *Mathematics as a gendered domain* scale consisted of three distinct (orthogonal) subscales. 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:

- MD: $\alpha = .902$
- FD: $\alpha = .897$
- ND: $\alpha = .836$

These values are similar to the split-half reliability of .87 reported by Fennema and Sherman (1976) for their MD 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 1. The data reveal that, in general, students did not gender stereotype mathematics. Mean scores were > 3 for perceptions of mathematics as a *neutral domain* and < 3 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*.

Table 1: Subscale means and standard deviations

Scale	N	Mean	SD
MD	736	2.33	.670

FD	750	2.70	.697
ND	738	3.84	.556

Bivariate Pearson product-moment correlations were found for each combination of subscales. The results are shown on Table 2.

Table 2: Pearson correlations

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

* p<.05 ** p<.01

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

Setting the scene

As already indicated, the themes tapped by the two scales overlapped closely. Items used in the second trial of the *Who and mathematics* scale are listed in Table 3. They illustrate in more detail the areas covered in our instruments. To provide a useful context for the data obtained from our administrations of the measures, the responses anticipated on the basis of previous findings reported in the relevant literature are also presented.

Table 3: Predictions based on previous research

ITEM	Predict	ITEM	Predict
1 Maths is their favourite subject	M	16 Distract others from maths work	M
2 Think it is important to understand the work	F	17 Get wrong answers in maths	F
3 Are asked more questions by the maths teacher	M	18 Find maths easy	M
4 Give up when they find a maths problem too difficult	F	19 Parents think it is important for them to study maths	M
5 Have to work hard to do well	F	20 Need more help in maths	F
6 Enjoy mathematics	M	21 Tease boys if they are good at maths	M
7 Care about doing well	M/F	22 Worry if they don't do well in maths	M/F
8 Think they did not work hard enough if don't do well	M	23 Are not good at maths	F

ITEM	Predict	ITEM	Predict
9 Parents would be disappointed if they don't do well	M	24 Like using computers to solve maths problems	M
10 Need maths to maximise employ opportunities	M	25 Teachers spend more time with them	M
11 Like challenging maths problems	M	26 Consider maths boring	F
12 Are encouraged to do well by the maths teacher	M	27 Find maths difficult	F
13 Maths teacher thinks they will do well	M	28 Get on with their work in class	F
14 Think maths will be important in their adult life	M	29 Think maths is interesting	M
15 Expect to do well in maths	M	30 Tease girls if they are good at maths	M

NB. The predictions are based on the findings reported in previous research. M indicates that the literature suggests that, on average, the item is more descriptive of boys' behaviours; F that the item is more descriptive, on average, of girls behaviours; M/F that the findings have been ambiguous.

More details about data obtained in the second trial with an Australian school sample are presented as part of the symposium and in Forgasz (2001). Also presented are results obtained when a slightly modified version of the instrument was administered to a sample of Australian preservice teachers. The results of administration of these questionnaires with American samples are presented by Kloosterman, Tassell, and Ponniah (2001). Finally, comparisons between the Australian data and those gathered from a group of American school students and pre service teachers are reported by Forgasz (2001).

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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. Varimax results for confirmatory factor analysis

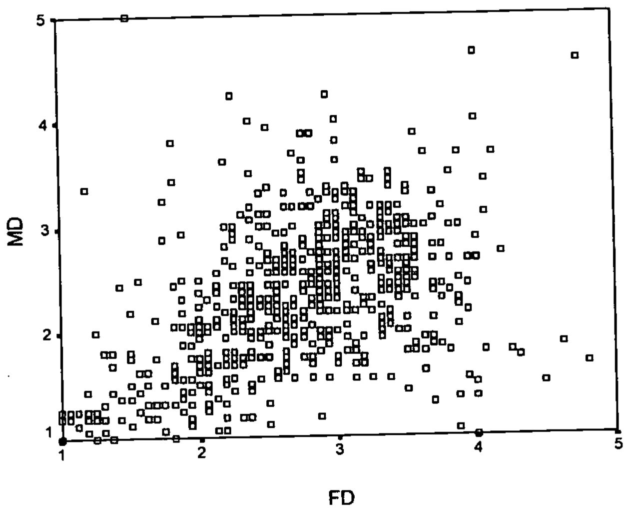

Figure 2. Scattergram for MD & FD scores

Note: subscale identity is designated by the first two letters of the item name (e.g., MDAbil1 – an 'ability' item on the *Mathematics as a male domain* subscale).

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