PRE-SERVICE PRIMARY TEACHERS' ATTITUDES TO TEACHING MATHEMATICS
A REAPPRAISAL OF A RECENTLY DEVELOPED INSTRUMENT

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Steven Nisbet (1991) recently published an article which reported on the development of an instrument for measuring pre-service teachers' attitudes to teaching mathematics. Although this was a worthy project we were not convinced by some of the conclusions drawn and suspected that the resulting twenty-two item instrument did not include the best indicators of attitude.

Definitions of attitude generally include the idea that attitudes manifest themselves in one's response to the object or situation concerned. One such definition states:

> "Attitude is a mental and neural state of readiness, organised through experience, exerting a directive or dynamic influence upon the individual's response to all objects and situations with which it is related".
>
> (Allport in Kulm, 1980, p 356)

When exploring the attitudes of preservice teachers toward mathematics it is necessary to not only consider their attitude towards the subject itself, but also their attitude regarding the teaching of mathematics.

The attitudes of pre-service teachers are of particular importance because of their potential influence on pupils. Although the research evidence is certainly not conclusive, it has been sufficient to suggest that positive teacher attitudes contribute to the formation of positive pupil attitudes (Aiken, 1972, 1976; Phillips, 1973; Sullivan, 1987). Some studies have indicated that teacher attitudes towards a subject and the teaching of that subject influence the instructional techniques they employ and that these, in turn, may have an effect on pupil attitudes (Brush, 1981; Carpenter and Lubinski, 1990; Williams, 1988).

Although there is little hard evidence that holding positive attitudes towards mathematics is actually beneficial, it is difficult to argue against their desirability. The widespread belief in the relevance of positive pupil attitudes towards mathematics is reflected in the following extract from the *National Statement on Mathematics for Australian Schools*,

> "An important aim of mathematics education is to develop in students positive attitudes towards mathematics and their involvement in it."
>
> (Australian Educational Council, 1991, p 31).

One argument presented in support of the need of positive attitudes is that such attitudes can enhance achievement in mathematics at primary, secondary and tertiary level (Dungan and Thurlow, 1989). Most studies on the relationship between attitude and achievement have revealed a low but significant correlation (Aiken, 1976; Kulm, 1980). However, the nature and direction of this relationship is yet to be unravelled (Daane and Post, 1989; Kulm, 1980; Suydam, 1984).

Research into attitudes has explored various components of attitude such as anxiety, enjoyment, self-concept and belief in the usefulness or value of mathematics. One component that has received much attention is that of "mathematics anxiety". There is no doubt as to the existence of 'mathematics anxiety' and a number of instruments for measuring levels of anxiety has been developed and implemented (Richardson & Suinn, 1972). However, Sovchik, Meconi, and Steiner (1981) suggest that the construct "mathematics anxiety" is not as well defined and measureable as assumed by some mathematics researchers. There is some doubt as to whether anxiety is in fact a separate construct. It may just be a reflection of some deeper attitude (Wood, 1988). Anxiety's relationships to other factors such as enjoyment, general attitude towards mathematics and performance are unclear. There is growing evidence that self-concept is a better measure of how people feel about themselves as teachers of mathematics, and that self-concept has an influence on the formation of attitudes. Studies have also found a consistently high positive relationship between self-concept and mathematics achievement (Hackett and Betz, 1989; Marsh, Cairns, Relich, Barnes, and Debus, 1984; Relich, Conroy, and Webber 1991; Reyes, 1984).

Comparisons of anxiety levels in males and females at primary, secondary and tertiary levels, have reported females to be generally more anxious about mathematics than males (Aiken, 1976; Kelly and Tomhave, 1985). Of particular concern is the notion that female teachers, who constitute the majority of primary school teachers, may be perpetuating negative attitudes with the girls in their classes (Kelly and Tomhave, 1985; Relich et al., 1991).

If it is accepted that it is highly desirable for teachers of mathematics to exhibit positive attitudes then the high proportions of pre-service teachers found to hold negative attitudes towards mathematics is somewhat alarming (Becker, 1986; Kelly and Tomhave, 1985; Sullivan, 1987).

Recent research with pre-service teachers has begun to reveal a series of links between mathematics attitudes, the choice or avoidance of mathematical studies, self-concept and attitudes towards the teaching of mathematics. It appears that students (both male and female) with low self-concepts in mathematics are less likely to pursue mathematical studies. Not surprisingly then, studies have revealed that most pre-service teachers who exhibit negative attitudes towards mathematics have not chosen to study mathematics in their final years of high school (Aiken, 1976; Relich et al., 1991; Sullivan, 1987). Some studies have gone as far as to recommend that appropriate minimum levels of mathematics study may need to become course entry requirements in order to raise the attitude levels (Mansfield, 1981; Relich et al., 1991).

The potential of teacher training courses to change the negative attitudes of pre-service teachers towards mathematics needs to be considered. Sullivan (1987) found that almost half of the students entering a teacher training course possessed negative attitudes towards mathematics. He states:

> "The course improved their attitudes overall, but those who started with negative attitudes still had the most negative attitudes at the end"
>
> (Sullivan, 1987, p.1)

He concluded that if these initial attitudes are so significant, teacher education courses may need to establish entry criteria based on the mathematics background of the applicants.

Several studies suggest that beginning teachers are especially concerned about methodology as well as content and therefore training courses should cater for this (Aiken, 1976; Blunden & De La Rue, 1990; Mansfield, 1981; Sovchik et al., 1981; Watson, 1987). Relatively high correlations have been found between mathematical achievement, the enjoyment of mathematics and the perception of mathematics being useful, which also carries the implications for the design of teacher education courses (Watson, 1987).

If the attitudes of preservice teachers are to be improved, there first needs to be a reliable instrument with which to measure levels of attitudes and perhaps to identify groups of students with special needs (Aiken, 1976; Nisbet, 1991; Watson, 1987). The original instrument used by Nisbet (1991) consisted of the Fennema-Sherman (1976) "Mathematics Attitude Scales" plus the parallel scales constructed by Nisbet to cover the 'Attitudes to Teaching Mathematics' aspect. Neither of these scales included items regarding self-concept, so they were supplemented by items developed by Marsh (1988).

METHOD

The information reported by Nisbet did not include complete correlation tables on factor loadings therefore it was not possible to reanalyse the data. Instead we opted to re-administer the battery of subscales used in the initial developmental stages as well as some additional self-concept items and to factor analyse the new data set to see whether a similar pattern of results would emerge.

Subjects

The battery of tests was administered to 345 pre-service students in the Diploma of Teaching/Bachelor of Education program at the University of Western Sydney, Nepean. All students in the three years of undergraduate study were invited to participate in the study in their normal class time for lectures in mathematics education. Approximately 20 students declined to participate. The subjects ranged in age from 17 years to 43 years with 39.6% classified as mature age students, over 21 years of age. Table 1 gives details of the age distribution of students with a mean of 23 years, a median of 20 years and a standard deviation of 6.9 years.

Table 1: Age distribution of the sample

Age	*n*	% of sample
17-21	212	62.5
22-25	42	12.4
26-30	20	5.9
>30	65	19.2

NOTE: 6 missing cases

The majority of the sample was female (79.1%) and was represented in similar proportions within the mature age group (73.8%) and recent school leavers (81.6%). The majority of these students had studied maths to Year 12 (88.5%) (see Table 2).

Table 2: Gender distribution of the sample by age group

Gender	Age 17-21		22-25		26-30		>30	
	n	%	*n*	%	*n*	%	*n*	%
Male	39	18.4	14	33.3	4	20	11	18.6
Female	173	81.6	28	66.7	16	80	48	81.4

NOTE: 12 missing cases

Table 3 gives a breakdown of level of study by age and gender. These results represent a group similar to Nisbet's sample of students. However, a larger proportion of students (10.3%) had completed tertiary mathematics discipline studies apart from units included in the teacher education program.

RESULTS

The Sample

In order to determine how the sample matched Nisbet's with reference to training in high school mathematics, we crosstabulated age group with study in high school mathematics, here defined by the NSW syllabus as Maths in Society, 2 unit, 3 unit and 4 unit at Year 12 level. For this group 10.8% studied Maths in Society and 51.7% and 12.9% two unit and three unit respectively. No students entered the program having studied four unit maths. Table 3 outlines the number of students with Year 12 maths in each age group.

Table 3: Level of study of high school mathematics by age group as a percentage of the total sample.

Age	% of sample	Year 10	Level of Study MS(1)	2 unit	3 unit
17-21	63.7	5.6	61.0	73.3	79.1
22-25	12.6	22.2	15.9	9.9	9.3
26-30	6.0	16.7	6.1	4.7	2.3
31 +	17.7	55.6	17.1	12.2	9.3

MS(1) Maths in Society

These results clearly indicate that mature age students in general have studied significantly less (Chi-Square = 70.06, $p<.001$) mathematics than their younger counterparts and conforms with Nisbet's findings. This further emphasises the serious implications for this group as entrants into primary teacher education programs without the requisite background in mathematics as recommended in the *Discipline Review of Teacher Education in Mathematics and Science* (1989).

Materials

The range of items described by Nisbet were included in a 65 item questionnaire designed to measure general attitudes to the teaching of mathematics. These scales were derived from the Fennema and Sherman (1976) attitude scales and the Marsh (1988) Self-Description Questionnaire.

The subscales include the *Confidence in teaching mathematics* (items 1, 9, 11, 17, 26, 41, 49, 53, 60); *Mathematics teaching anxiety* (items 2, 18, 27, 32, 37, 38, 42, 51, 54, 61); *Attitude toward success in teaching mathematics* (items 3, 12, 19, 43, 55, 62); *Mathematics teaching as a male domain* (items 4, 13, 21, 28, 22, 44, 56, 63); *Usefulness of teaching mathematics* (items 6, 14, 22, 29, 34, 46, 57, 65); *Effectance motivation in teaching mathematics* (items 7, 16, 23, 31, 36, 39, 47, 52, 58, 64); *Perception of teacher's/lecturer's attitudes towards one as a teacher of mathematics* (items 8, 24, 48, 59); and, *self-concept in mathematics* (items 5, 10, 15, 20, 25, 30, 35, 40, 45, 50).

Nisbet argued against the inclusion of mother's and father's *attitudes towards one as a teacher of mathematics* on the grounds that a large proportion of the sample (up to 50%) indicated that they were undecided or did not respond to these items. He does not include these items in his final scale. In the interest of limiting the number of items included in our questionnaire and in order to include the Marsh self-concept items without lengthening the questionnaire unduly, we decided to eliminate this set of items from our questionnaire.

Design

The sixty-five items were factor analysed using principal axis factoring with varimax rotation (using SPSS-X). A six factor solution was identified as being the most appropriate in isolating six distinct scales to identify attitudes.

Regression analyses using stepwise procedures were then used to determine whether differences in attitudes could be predicted from the set of variables identifying participant characteristics such as age, gender, and educational background. Analyses of variance and t-tests were also used to determine whether differences in attitudes could be identified based on these characteristics and subsequent subscale scores derived through the factor analysis.

Factor Analysis

A six factor solution using principal axis analysis and varimax notation resulted the clearest distribution of items into identifiable subscales. Two major factors emerged which measure two similar but distinct aspects of self perceptions related to mathematics: individual attitudes of pre-service teachers as *teachers of mathematics* (ATM) and their self-concept *as mathematicians* (MSC). In addition, we found evidence for a distinct *mathematics teaching as a male domain* (MTMD) scale, *usefulness of teaching mathematics* (UTM), *excellence as a teacher of mathematics* (ETM) scale and an *other's perceptions of me as teacher of mathematics* (OTM) scale. Table 4 lists the factor loading of each item on each of these scales.

Table 4: Factor loading of 65 item questionnaire on six factors

	Factor					
Item No	ATM(1)	MSC(2)	MTMD(3)	UTM(4)	ETM(5)	OPTM(6)
7	84					
32	81					
2	75					
16	74					
37	73					
27	72					
60	71					
36	70					
1	66					
61	65					
42	65					
53	65					
58	64					
17	64					
39	63					
18	61					
51	59					
49	59					
8	59					
64	56					
52	56					
5	55					
38	55					
41	54					
50	53					
26	51					
11	49					
9	46					
47	46					
54	40					
35		73				
45		68				
25	44	65				
20		60				
40		60				
10		55				
15	40	54				
30		53				
28			68			
33			67			
4			58			
31			57			
44			57			
13			53			
21			49			
56			47			
63			43			
23			-			
22				79		
34				77		
14				72		
6				63		
57				54		
29				46		
65				45		
43					66	
55					59	
12					47	
62					-	
3						57
19						42
46						-42
48						-
59						-
24						

Note: Decimal points are omitted. Values less than .40 are not included

(1) ATM: Attitude to teaching mathematics
(2) MSC: Mathematics self-concept
(3) MTMD: Mathematics Teaching as a male domain
(4) UTM: Usefulness of teaching mathematics
(5) ETM: Excellence as a teaching of maths
(6) OTM: Other's perceptions as a teacher of maths

The first scale which consists of an amalgamation of 30 items from a variety of the original subscales tends to reflect a general attitude towards the teaching of mathematics. In fact all bar two items specifically mention the act of teaching as part of the content. The coefficient alpha reliability was .96.

The second factor (coefficient alpha = .89) on the other hand, reflects eight of the ten Self-Description Questionnaire items and is specifically relevant to personal performance on mathematical tasks. All of these items load to some extent on the first factor but form a distinct separate factor.

The third factor (coefficient alpha = .79) includes all of the items from the *mathematics teaching as a male domain subscale* and two items from the *effectance motivation in teaching mathematics* scale but the loading of one of these items is very low.

The fourth factor (Coefficient alpha = .78) contains seven of the eight *usefulness of teaching mathematics* scale.

The last two factors which emerge are not as clearly delineated, nor as reliable as the first four, but may be identified as *excellence as a teacher of mathematics* (coefficient alpha = .57) scale and *other's perceptions of me as a mathematics teacher* (coefficient alpha = .29) scale.

Further Analysis

The total scores on the subscales which emerged were correlated with each other and the set of independent variables which described the general characteristics of the group of participants; age, gender, years of study of high school mathematics and tertiary mathematics. These results are reported in Table 5.

Table 5: Correlations among the full set of independent variables and the emergent factorial subscales

	Age(1)	Gen(2)	HSC(3)	TER(4)	ATM(5)	MSC(6)	MTDM(7)	UTM(8)	ETM(9)
GEN	00								
HSC	-35***	-05							
TER	-01	-16**	15**						
ATM	04	-06	03	-07					
MSC	-21***	-12*	35***	08	75***				
MTMD	-06	23***	-03	-23***	27**	12**			
UTM	13	10	-13*	-06	05	01	38***		
ETM	-03	01	-01	-05	20*	26***	31***	17*	
OPTM(10)	09	-08	06	08	17*	11	23**	33***	17*

Note: Decimal points omitted

* p < .05
** p < .01
*** p < .001

(1) Age: Age
(2) Gen: Gender
(3) HSC: Years of study (maths) at high school
(4) TER: Years of study (maths) at tertiary level
(5) ATM: Attitude to teaching mathematics
(6) MSC: Mathematics self-concept
(7) MTMD: Mathematics teaching as a male domain
(8) UTM: Usefulness of teaching mathematics
(9) ETM: Excellence as a teacher of mathematics
(10) OPTM: Other's perceptions as a teacher of maths

One of the other major differences in the findings of this research in contrast to Nisbet's is the inclusion of *mathematics teaching as a male domain* subscale in the item pool to be analysed. Not only did this set of items clearly stand out as a separate construct but further analyses of the subscale showed that there are significant differences ($t=4.17$, $p<.001$) in response with females scoring higher than males (Female: $M=74.4$, $SD= 6.2$ vs Male: $M=70.7$, $SD = 6.6$). It is debatable whether such a statistical difference is important as both groups score very high overall (maximum score possible 80). The only other significant difference ($t = 3.9$, $p<.001$) in response between males and females was found for the *mathematics self-concept* subscale with males ($M= 45.1$, $SD= 10.4$) scoring higher than females ($M=39.5$, $SD=11.9$) (maximum score possible = 64). This is consistent with all the current literature which does indicate a consistent trend for males to rate themselves more highly than females on this construct.

The regression analysis did not lead to any major findings. While attitude to teaching mathematics was not predictable from the set of independent variables, mathematics self-concept is clearly predictable from level of study of high school mathematics. Attitudes towards *teaching mathematics as a male domain* can be predicted from gender (males are more likely to see it as a male domain than females) and level of tertiary study (students with greater tertiary training are more likely to see it as a male domain than students with *no* tertiary training). Tables 6 and 7 outline the regression equation.

Table 6: Regression analysis of hypothesised predictions on self-concept

Source	**Multiple R**	**ΔR^2**	**$\Delta R^{2\#}$**	**beta**	**F^F**
HSc	.345	.119	.119	.345	36.2*

*p < .001
ΔR^2 = the added percentage of predicted variance accounted for by the inclusion of the variable to the regression equation.
F_F determines the significance of the contribution of the individual variable.

Table 7: Regression analysis of hypothesised predictors on mathematics teaching as a male domain

Source	**Multiple R**	**ΔR^2**	**$\Delta R^{2\#}$**	**beta**	**F^F**
GEN	.234	.055	.234	.203	17.027*
TER	.304	.043	.038	-.197	14.900*

*p < .001
ΔR^2 = the added percentage of predicted varince accounted for by the inclusion of the variable to the regression equation.
F_F determines the significance of the contribution of the individual variable.

DISCUSSION AND CONCLUSION

This factor structure does not conform to the Nisbet factor pattern which defines both a confidence and an anxiety factor. He states:

> "anxiety and confidence in teaching mathematics are independent factors. They are not opposite extremes of the one continuum. The most confident students are not necessarily the least anxious" (p. 45).

The factor structure we propose does not differentiate between anxiety and confidence rather it combines these two scales along with the restructured Sherman and Fennema (1976) *Effectance Motivation* scale, into a conglomerate scale which seems to reflect general attitude to the teaching of mathematics and personal feelings towards this activity. Interestingly, the self-concept items derived from the Marsh (1988) Self-Description Questionnaire constitute a distinct factor but one which shares considerable variance (55%) with the initial factor, suggesting that attitudes and confidence (here derived from the self-concept variable) are inextricably associated. In contrast to Nisbet's results, these results suggest that personal perceptions of one's adequacy as a mathematician should impinge on attitudes to teaching mathematics and are part of a continuum.

The evidence for mathematics anxiety as a separate construct, particularly as a construct different from confidence, is not convincing as has been argued in the literature review. The factor structure which emerged from the analyses of this set of data provides additional evidence for this point of view.

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