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Gender Differences in Mathematics Anxiety Among Preservice Teachers and Perceptions of Their Elementary and Secondary School Experience with Mathematics

This study investigated experiential antecedents of mathematics anxiety and associations with gender among preservice student teachers. Participants were 357 students enrolled in the final year of a teacher education program. They responded to the Mathematics Anxiety Rating Scale (Richardson & Suinn, 1972) and a questionnaire to assess experience with mathematics in the elementary and secondary school together with attitudes toward mathematics and beliefs about the subject. Male and female participants did not differ in formal mathematics achievement or the time elapsed since taking a mathematics course. Several gender differences were found in perceptions of school mathematics experience, and both men and women reported greater enjoyment of mathematics in elementary school compared with high school. Women expressed less positive beliefs about their use of, and intrinsic interest in, mathematics. Associations between mathematics anxiety and both perceptions of school experience and beliefs about mathematics were higher for women. Negative experience with mathematics in high school was an important precursor of mathematics anxiety, especially among women. Some implications for teacher education programs were reviewed; these emphasize the importance of both teachers' and peers' behavior, especially in the high school environment.

Cette étude s'est penchée sur les antécédents expérientiels de mathophobie et l'influence du sexe d'un groupe de 357 stagiaires dans la dernière année de leur diplôme en pédagogie. Les participants ont complété une évaluation de la mathophobie (Mathematics Anxiety Rating Scale, Richardson & Suinn, 1972) et un questionnaire où ils ont évalué leurs expériences avec les mathématiques à l'élémentaire et au secondaire, décrit leurs attitudes face aux mathématiques et leurs croyances quant au domaine. Le rendement en mathématiques des hommes était semblable à celle des femmes, et le temps qui s'était écoulé depuis leur dernier cours de mathématiques était le même pour tous. Toutefois, sur le plan de l'expérience avec les mathématiques à l'école, les perceptions des hommes différaient de celles des femmes. Tant les hommes que les femmes ont indiqué avoir trouvé les mathématiques plus agréables à l'élémentaire qu'au secondaire. Les femmes ont exprimé des croyances moins positives quant à l'usage qu'elles faisaient des mathématiques et l'intérêt intrinsèque qu'elles portaient au domaine. La corrélation entre la mathophobie d'une part et les perceptions quant à l'expérience scolaire et les croyances concernant les mathématiques d'autre part était plus élevée pour les femmes. Une expérience négative avec les mathématiques s'est avérée être un facteur précurseur important dans la mathophobie, surtout chez les femmes. Les auteurs proposent

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quelques liens entre ces résultats et les programmes d'études en pédagogie et soulignent l'importance du comportement de l'enseignant et des pairs, surtout à l'école secondaire.

There has been only limited study of the prevalence of mathematics anxiety among education students training to become teachers. This is significant in the light of the importance widely attributed to teachers' differential treatment of boys and girls in mathematics classes. Most elementary teachers are women, and most secondary mathematics teachers are men (Ontario Ministry of Education, 1999); it is important to understand their attitudes toward mathematics and how these might be transferred to their students. The chief purpose of this study is to describe the nature of gender differences in mathematics anxiety among preservice student teachers. This includes examination of differences in expressed beliefs and attitudes toward mathematics along with reported relevant experience in elementary and secondary school environments.

Mathematics anxiety has been used to help explain avoidance of mathematics and low mathematics performance by students at all levels, along with poor mathematics instruction by teachers who have difficulty teaching the subject through lack of confidence that stems from anxiety (Buhlman & Young, 1982; Hadfield & McNeil, 1994; Kelly & Tomhave, 1985). It has been claimed that many teachers enter professional education courses lacking fundamental skills and understanding in mathematics (Manouchehri, 1998).

Although mathematics anxiety has been studied extensively in several populations, little empirical evidence exists regarding its significance and possible consequences among preservice teachers. Hadfield and McNeil (1994), in a study of 151 elementary student teachers, investigated relationships between personality type and mathematics anxiety. Using the Myers-Briggs Type Indicator they found an association between the thinking-feeling scale and mathematics anxiety, noting that less analytical, more feeling persons are attracted to elementary teaching and are likely to be more sensitive to the needs of children. The authors raised the possibility of employing specialist mathematics teachers under certain circumstances in elementary classrooms. The examination of gender equity in preservice teacher education classes, especially in relation to mathematics, science, and technology, appears to be minimal (Campbell & Sanders, 1997).

Mathematics anxiety, defined as "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (Richardson & Suinn, 1972. p. 551) has been associated with gender in numerous studies (Meece, Wigfield, & Eccles, 1990; Pajarees & Urdan, 1996). Women have been found consistently to score higher on measures of mathematics anxiety. However, the nature and importance of the correlation has been disputed (Felson & Trudeau, 1991; Flessati & Jamieson, 1991). The relationship between gender and mathematics anxiety, evident in studies of adolescent and adult samples, has not been found consistently among elementary students (Pajares & Miller, 1995). This is compatible with the observation that girls regularly outperform boys in elementary school mathematics, implying that increased mathematics anxiety contributes to a decline in their performance in high school and beyond (Hyde, 1993). There is evidence that mathematics anxiety interferes with performance. Ashcroft and Kirk (2001)

found that individuals with high mathematics anxiety demonstrated smaller working memory span, particularly for computational tasks, thus reducing task completion.

Mathematics anxiety is a complex construct. Factor analysis of the Mathematics Anxiety Rating Scale MARS (Richardson & Suinn, 1972), a widely cited measure, has resulted in varying interpretations. Rounds and Hendel (1980) suggested that mathematics test anxiety and numerical anxiety are distinctive components, to which Ferguson (1986) has added abstraction anxiety. Research with a 25-item revised MARS (Alexander & Martray, 1989) suggests that mathematics anxiety has three consistent components: mathematics test anxiety, numerical task anxiety, and mathematics course anxiety. Factor analyses of several measures of mathematics anxiety have indicated a variety of relationships between components of mathematics anxiety and perceptions of mathematics (Bessant, 1995; Casey, Nuttall, & Pezaris, 1997). Both women and men perceive mathematics as a masculine domain in which men are more competent and those women who exhibit success are less feminine (Eccles, Wigfield, Harold, & Blumfeld, 1993), despite the superior academic performance of girls in the elementary grades. Further, it has been proposed that mathematics anxiety results in the individual taking fewer mathematics courses with consequent limits to career choice, particularly in technical and scientific fields (Hackett, 1985; Hendel, 1980).

Hembree (1990) conducted a meta-analysis of 151 studies of mathematics anxiety and found that it consistently related to poor performance on mathematics achievement tests. He argued that mathematics anxiety suppresses achievement and that there is no compelling evidence that poor performance causes mathematics anxiety. Hembree also noted that preservice arithmetic teachers were especially prone to mathematics anxiety and that positive attitudes toward mathematics consistently related to lower mathematics anxiety. Mathematics anxiety was found to be consistently higher for girls, with average levels increasing from grade 6, peaking near grades 9 and 10, and levelling off in college.

The study of gender differences in mathematics achievement and anxiety has resulted in an extensive literature concerning possible underlying biological and socialization factors. Benbow and her colleague (Benbow, 1988; Benbow & Lubinski, 1993) have proposed that gender differences in spatial ability are partly biological and contribute to differences in mathematics achievement and consequent anxiety. Others (Crawford, Chaffin, & Fitton, 1995) disputed a biological contribution to gender differences in spatial ability. They argued that socialization in the home and school environments fosters the development of negative attitudes and lower expectations of success as part of the female sex role. Wigfield and Eccles (1992) described a model in which perceived success or failure (as distinguished from actual success or failure) influences girls' beliefs about their potential for success in mathematics. Accordingly, mathematics anxiety is not simply a product of the experience of failure, but a consequence of stable internal attributions of low ability.

In the search for causes of gender differences in mathematics achievement and anxiety researchers have focused on experience in the home and school, as well as the media (Casey et al., 1997; Fennema, Walberg, & Marrett, 1985).

Mathematics anxiety was found to be associated with age among female college students and years of high school mathematics study for both men and women (Betz, 1978). In the same study older women reported much higher anxiety, a result that may reflect the greater passage of time since completing a formal mathematics course or changes in teaching methods over time. Betz pointed out that "high school math preparation strongly influences how a college student will feel about math" (p. 446).

The significance of high school experience has infrequently been distinguished from elementary school experience in the literature. For example, the American Association of University Women's (1995) report *How Schools Shortchange Girls* attributed lower success (and higher anxiety) to the differential treatment of boys and girls in "the school system." Citing work by Leder (1990) and others, the report argued that teacher behavior is critical in limiting girls' achievement and increasing their anxiety about mathematics. Among the variables the report claims contribute to "a sharp loss of mathematics self-confidence" (Casey et al., 1997, p. 671) are time spent by teachers with male students, teachers' oral interaction with boys, and the perceptions of students that teachers give more attention to boys.

Mathematics Anxiety Among Preservice and Practicing Teachers

Teachers' behavior has been hypothesized to be a critical factor in the development of mathematics anxiety, particularly in the elementary school. Swetman, Munday, and Windham (1993) proposed that mathematics anxiety among elementary teachers related to the development of negative attitudes toward mathematics among their students, resulting ultimately in depressed achievement. Experience in elementary school has been widely assumed to be the primary source of mathematics anxiety and avoidance. For example, Hackworth (1985) and Hadfield and McNeil (1994) have argued that "the disproportionately large number of mathematically anxious teachers at the elementary school level ... may promote the early onset of mathematics anxiety among their students" (p. 376).

Models designed to explain gender differences in mathematics achievement and anxiety have focused on socialization processes (Fennema et al., 1985). Parental influences have been considered of primary importance in some studies. For example, it has been argued that parents encourage their sons' mathematical studies more than those of their daughters (Fennema & Sherman, 1977; Luchins & Luchins, 1980). Other investigators have focused on the school, particularly teacher behavior (Sadker & Sadker, 1994). However, the transition between elementary and secondary school and the move from early to middle adolescence has received less attention in model development, although these both coincide with a decline in girls' mathematical interests and achievement together with a significant increase in their mathematics anxiety.

In a review of theory development in the area, Leder (1985) noted that gender differences in adolescence had been associated with "peer group values" and traditional gender role socialization, implying that experience in high school may be as significant as that in elementary school. It may be that the influence of peer groups in both childhood and adolescence has been underestimated, and the contributions of teachers overestimated, in the development of beliefs attaching to gender (Harris, 1995). In coeducational high

schools and postsecondary institutions, the stronger stereotyping by men of mathematics as *masculine* (Hyde, 1993) has a direct and negative effect on women's behavior. The increased avoidance of mathematics by young women in high school and college may be better understood by taking more account of the effects of the environment beyond elementary school.

Method

Participants

Participants were 357 students (242 women, 115 men) enrolled in a compulsory final-year teacher education course in special education at a small Canadian university. Because the course was compulsory, participants represented both elementary and secondary divisions with a variety of academic majors. (Frequencies by division were primary-junior 134, junior-intermediate 104, intermediate senior 119.) Participation was voluntary and anonymous, and there were no refusals. Participants ranged in age from 21 to 53 years with means of 25.58 years, SD=5.57 (women) and 26.55 years, SD=5.34 (men). This study formed part of a larger investigation of mathematics anxiety and perceived teaching competence.

Instruments

Mathematics anxiety was measured using the Mathematics Anxiety Rating scale MARS (Richardson & Suinn, 1972). The scale consists of 98 Likert-format items designed to assess mathematics anxiety in both daily life and academic situations. Participants also completed a questionnaire constructed by the investigators designed to measure relevant mathematics background experience, perceptions of school experience with mathematics, and beliefs about mathematics. The questionnaire further included one five-point Likert format item "I feel anxious when doing mathematical problems." Background experience items addressed participants' highest level of formal mathematics study, whether that study was at an advanced or general level, and the number of years since formal coursework had been completed. Perceptions of school mathematics experience and beliefs about mathematics were measured using seven statements in a five-point Likert format (1=strongly disagree through 5=strongly agree). The items related to participants' enjoyment of mathematics in elementary and high school, whether they experienced teaching by rote in high school, and their beliefs about the intrinsic interest and practical uses of mathematics. An open-ended item permitted participants to write in "any comments related to this survey." These were later coded for gender, division, and emerging themes.

It was anticipated that higher levels of mathematics anxiety would be apparent for women and that they would express more negative beliefs about mathematics. Women were also expected to report more negative perceptions of their school experience with mathematics, particularly in high school. Gender differences were not predicted for background variables including level of formal study and the length of time since last taking a course in mathematics.

Results

A significant gender difference was found for mathematics anxiety. The mean MARS score for women was 204.3 (SD=68.41), and the mean score for men was

173.41 (*SD*=54.59), a difference significant at the .001 level (t=4.24). These scores are higher than those reported for statistics students (Hunsley & Flessati, 1988), but lower than those reported for introductory psychology students (Flessati & Jamieson, 1991). Participants also responded to a five-point Likert format item in the questionnaire prepared by the researchers: "I feel anxious when doing mathematical problems." A higher score indicates agreement. The mean for women was 3.26 (*SD*=1.33), and the mean for men was 2.74 (*SD*=1.21), t=3.56, p<.001. The correlation between this item and total MARS score was .57, p<.001.

Mathematics Background Experience

There were no gender differences in the level of formal mathematics education taken. This was assessed by having respondents check one of seven categories ranging from "less than grade 10" through "beyond first-year university." Mean score for men was 5.29 (*SD*=1.34), for women 5.10 (*SD*=1.32). Category five corresponded to Ontario advanced credits (OAC), a transition year between high school graduation and university entry. Sixty-nine percent of men reported their highest level of formal mathematics education as grade 12, OAC, or first-year university compared with 75% of women. More men reported study beyond first-year university (22%) compared with women (14.5%). Eighty percent of women and men reported their highest level of study was "advanced" rather than "general." There were no gender differences in reported time since last taking a formal mathematics course. The mean for women was 6.31 years (*SD*=5.70), for men 7.07 years (*SD*=5.22), t=0.23, NS.

Perceptions of Mathematics School Experience

Significant gender differences emerged in perceptions of experience with mathematics when in school (Table 1).

Men were more likely to agree that "in high school my learning of mathematics was mostly by rote," and women were more likely to agree that "mathematics was the subject I liked least in school." Men were more likely than women to report enjoying studying mathematics at high school; however,

Table 1
Gender Differences for Perceptions of School Experience in Mathematics

	Male		*Female*		
Variable	*M*	*SD*	*M*	*SD*	*t*
In high school my learning of mathematics was mostly by rote	3.73	1.03	3.42	1.09	2.56**
I enjoyed studying mathematics in high school	3.17	1.27	2.90	1.45	1.70*
I enjoyed studying mathematics in elementary school	3.58	1.26	3.51	1.34	.48
Mathematics was the subject I liked least at school	2.52	1.33	2.90	1.53	2.26*

Note. Degrees of freedom for the t tests were 355.
*p<.05, **p<.01 (one-tailed tests).
Items employed five-point Likert-type response scale scored 1 "strongly disagree" through 5 "strongly agree."

there was no significant gender difference for perceived enjoyment of mathematics in elementary school. However, among both men and women there was greater agreement with the statement "I enjoyed studying mathematics in elementary school" than with the statement "I enjoyed studying mathematics in high school." The means for these two items were compared in gender groups, and significant differences were found for both (men: t=–3.28, p<.001; women: t=–6.96, p<.001). The open-ended item requesting any comments related to the questionnaire attracted responses from 62 individuals, of whom 14 referred to differential mathematics learning experiences in elementary school and high school. Eight of these were female elementary student teachers. The following are representative examples; however, it must be emphasized that they are merely illustrative and are not included to support or dispute the statistical data.

> I did not have much encouragement from math teachers in high school. My perception of my teacher's view of my math difficulties is that I was inferior or "stupid" because I required additional help or explanations. I associated being good in math as a male quality. (female, primary-junior)
>
> I enjoyed math in the primary grades, but after that the lessons progressed beyond my abilities and I continued to drop further behind. In high school math was a nightmare and a source of humiliation. I was gifted in English and did very well in other subjects, so I think teachers were unwilling to address my specific problems with math. (female, junior-intermediate)
>
> I love math and it was my most exciting course in the elementary school. (male, junior-intermediate)

Beliefs About Mathematics

The three items that assessed participants' beliefs about mathematics produced small but statistically significant differences (Table 2).

Men were more likely to perceive mathematics as useful and practical and to agree with the statement "mathematics is intrinsically interesting." Women were more likely to agree with the item "most of the mathematics I have

Table 2
Gender Differences in Beliefs about Mathematics

	Male		Female		
Variable	*M*	*SD*	*M*	*SD*	*t*
Mathematics is a useful and practical subject	4.34	.76	4.02	.86	3.41***
Mathematics is intrinsically interesting	3.36	1.10	3.00	1.17	2.74**
Most of the mathematics I learned has been of little use	2.81	1.18	3.04	1.14	1.75*

Note. Items employed a five-point Likert type response scale scored 1 for "strongly disagree" through 5 for "strongly agree."
Degrees of freedom for the t tests were 355.
*p<.05, ** p<.01, ***p<.001 (one-tailed tests).

learned has been of little use." The following open-ended response helps illustrate this point.

> It's hard to remember how I felt 20 years ago. As well I worked for 11 years in a bank so practical applications of math are no problem. The abstract stuff—algebra, geometry etc. totally confound me. I had to take math over in summer school, all four years of high school, because I kept flunking. But I volunteer to do everyone's income tax. Go figure! (female, intermediate-senior).

Relationships Between Mathematics Anxiety and Other Variables by Gender

Table 3 shows the association between mathematics anxiety (MARS total score) and background, perceived experience, and beliefs for each gender. The only background variable that consistently predicted mathematics anxiety was the highest level of formal mathematics study.

Whether that study was at an advanced or general level failed to predict mathematics anxiety, a result attributable to the low variance in both groups. Although the correlation between time since last taking a formal mathematics course and mathematics anxiety achieved statistical significance for men, it was low and in the unanticipated direction.

The association between mathematics anxiety and reported mathematics experience are higher for women, with enjoyment of mathematics in high school and agreeing mathematics was the subject liked least correlating highly with anxiety for women. Beliefs about mathematics showed moderate associations with mathematics anxiety for women. In the male sample, beliefs that mathematics is practical and personally useful did not relate to mathematics anxiety. The belief that mathematics is intrinsically interesting showed a moderate negative association with mathematics anxiety among male respondents.

Discussion

The gender differences among student teachers in mathematics anxiety found in this study are consistent with widely reported findings for a variety of other

Table 3
Correlations Between Total MARS Score and Background, Mathematics Experience and Beliefs About Mathematics by Gender

Variable	*r*	
	Men	*Women*
Highest level of formal education in mathematics	−.27**	−.35***
Level of highest mathematics studied (advanced/general)	.14	−.01
Years since last formal mathematics study	.19*	.05
In high school my learning of mathematics was mostly by rote	.22*	.29***
I enjoyed studying mathematics in elementary school	−.24**	−.37***
I enjoyed studying mathematics in high school	−.36***	−.50***
Mathematics was the subject I liked least at school	.47***	.51***
Mathematics is a useful and practical subject	.09	−.24***
Mathematics is intrinsically interesting	−.29**	−.37***
Most of the mathematics I have learned has been of little use	.12	.25***

*$p<.05$, **$p<.01$, ***$p<.001$ (two-tailed tests).

populations. Although some (Hyde, Fennema, Frost, & Hopp, 1990) have speculated that women more readily admit to anxiety or that mathematics anxiety is a form of more general test-taking anxiety, the present investigation is not so much concerned with the structure of mathematics anxiety as its functional consequences, particularly for women. As well, a number of factors emerged in this study that bear on questions about practical implications in elementary and secondary classrooms, as well as the genesis and development of mathematics anxiety.

The male and female student teachers who participated in this investigation did not differ in the extent of their formal mathematics education. Most had completed five years of secondary mathematics at an advanced level because of admission requirements for the teacher education program. Therefore, any gender differences that appeared in this study cannot be attributed to underlying differences in mathematics achievement. Furthermore, because men and women did not differ in the time that had elapsed since last taking a formal mathematics course, this variable may also be eliminated as a possible determinant of gender differences in mathematics anxiety for the present samples.

It should be noted that more men studied mathematics beyond first-year university than women even though their achievement before university was equivalent. It would appear that young women who are considering teaching as a profession, and have consequently been required to complete mathematics in high school at the same level as prospective male teachers, nevertheless adhere to the stereotype of mathematics as a masculine domain and avoid the subject at university. Further, female participants reported less positive beliefs about mathematics. Although the differences are not large, they are consistent: women were less likely to believe mathematics is useful, practical, and of personal use, or that it is intrinsically interesting. These beliefs about mathematics raise some doubt about the assertion that differences in mathematics anxiety are simply a function of women's tendency to admit to fears and anxiety more readily.

Perceived School Experience and Mathematics Anxiety

Many researchers who have assumed a socialization model for gender differences in mathematics anxiety and achievement have proposed that the elementary classroom is the place where mathematics anxiety is learned, so that less attention has been directed toward socialization in the high school (American Association of University Women, 1995; Leder, 1995; Sadker & Sadker, 1994). Differential treatment of girls and boys by elementary school teachers is often cited as the chief factor. Leder (1995), for example, contended that the key to the reduction of mathematics avoidance among girls is to create "a classroom environment open and supportive for all students" (p. 217). Analyses that focus exclusively on teachers' behavior in the elementary classroom do not account for the marginally superior achievement of girls at the elementary level. Nor do they recognize that an empirical link has yet to be demonstrated between teachers' mathematics anxiety and their students' attitudes toward mathematics in the elementary grades, despite claims to the contrary (Swetman et al., 1993).

The present results suggest that the development of mathematics anxiety should be examined in the context of socialization experience in the middle

school or high school as well as the elementary school. Both women and men reported enjoying studying mathematics in elementary school to the same degree; however, both (but especially women) reported a lower level of enjoyment of mathematics in high school. Women were also more likely to perceive their mathematics learning to be by rote in high school (Table 1). These perceptions imply that the development of mathematics anxiety for both sexes, but particularly for women, is associated with socialization in high school. The fact that most elementary teachers are women and most secondary mathematics teachers are men (Ontario Ministry of Education, 1999) means that many girls are exposed to women as mathematics role models before puberty, but less so during early and middle adolescence.

The importance of mathematics experience in the high school for the development of gender differences in mathematics anxiety is further supported by moderate to high negative correlations between reported enjoyment of high school mathematics and anxiety. Among women this relationship was high. However, there are also low (for men) and moderate (for women) negative correlations between mathematics anxiety and reported enjoyment of elementary mathematics, implying that mathematics anxiety begins in the elementary grades and that high school experience hastens its growth, particularly for women (Table 3). Of course, it should be recognized that an association between mathematics anxiety and enjoyment is complex. Some individuals may have low mathematics anxiety and find little enjoyment in routine mathematical tasks, whereas others, such as mathematics majors, may have low anxiety and experience high enjoyment of mathematics.

Beliefs about mathematics (e.g., its practical value and personal usefulness) are less positive among women and are better predictors of mathematics anxiety among them than for men. One possible inference is that these kinds of beliefs develop, along with an increase in mathematics anxiety, during the high school years, and may provide a rationalization for subsequent mathematics avoidance, especially among young women.

If gender differences in mathematics anxiety begin to appear in the upper elementary grades and show growth in the high school, it may be possible to attribute them in part to a greater emphasis on mathematical reasoning in the secondary curriculum and the predominance of male role models. The peer group may well play a large role in fostering increasing mathematics anxiety among women (at both the elementary and secondary levels). There is a need for research on the stereotyping of mathematics as masculine (particularly by men) and the dynamics of peer group influence regarding this among adolescents. However, the literature concerning student variables predominantly consists of research conducted in elementary classrooms and focusing on individual differences in cognition, motivation, risk-taking, fear of success, and attributional style (Leder, 1992, 1995).

The chief inference made in the present study is that gender differences in mathematics anxiety for student teachers are associated with experience during high school to a significant extent, and at least comparable to that in elementary school (where they first emerge). Gender differences in teenage society are salient, and women learn to avoid behavior considered masculine and tolerated during childhood.

Limitations and Conclusions

To summarize, consistent with other research on gender differences in mathematics anxiety, the women in the present study scored higher on a standardized measure of mathematics anxiety. Negative experience with mathematics, particularly at the high school level, was a precursor of mathematics anxiety, especially for the female preservice student teachers in this investigation.

Research on gender differences in mathematics reflects a broader concern than traditional dispassionate scholarship, namely, the roles of women and girls in society and how these are influenced by mathematics experience (Fennema & Hart, 1994). Fennema and Hart have discussed the publication policy of the *Journal of Research in Mathematics Education* in this context, contending that researchers are obliged to consider the social effect of their work, particularly in regard to gender differences. However, they suggest that research conducted in the traditions of empirical social science (the approach that guided the present study) along with work guided by feminist-standpoint epistemology both have contributions to make in this field.

The differences found in the present study between men and women regarding mathematics anxiety and beliefs about mathematics (such as its utility and intrinsic interest) were statistically significant and consistent with other observations reported in the literature. However, it must be stressed that they were small. Caution must be exercised in considering the implications for practice because gender is only one of several variables that is associated with mathematics anxiety.

Direct study is needed about the role of high school experience in the transmission of gender differences in mathematics achievement and anxiety. The present study was retrospective, and perceptions of experiences in the elementary and secondary school will have been influenced by subsequent experience. Most participants reported an advanced level of mathematics achievement in high school, limiting generalization from this sample of student teachers to others not having comparable mathematics achievement. Also, the correlational design of the investigation means that definitive statements about causality cannot be made without further controlled study. The roles of teacher behavior and group dynamics in the transmission and reinforcement of mathematics anxiety and negative beliefs about mathematics in young women requires further research. This is particularly so in the context of the transition from elementary to high school. The focus of much earlier research on teacher behavior in the elementary school as the principal factor influencing gender differences in mathematics achievement and anxiety may need to be reexamined. The effects high school teachers have on the development of mathematics anxiety deserves further scrutiny by placing it in the broader context of students' social behavior in groups during their secondary schooling. Teacher education programs need to address gender differences in mathematics anxiety among future teachers in both the elementary and secondary school. Efforts to intervene in the mathematics education of girls (Secada, Fennema, & Adaijian, 1995) have largely ignored the role of the peer group in mediating attitudes and beliefs about mathematics and linking these to gender. The assumption that specialist teachers are responsible for mathematics in-

struction in high school, and that therefore mathematics avoidance by girls in adolescence is a function of elementary school experience, fails to address the fact that mathematics is a part of all school subjects as well as daily living. All teachers need to model positive attitudes and beliefs about mathematical concepts and skills.

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