Factors Associated With Mathematics Achievement and Participation in Advanced Mathematics Courses: An Examination of Gender Differences From an International Perspective

Kadriye Ercikan, Tanya McCreith, and Vanessa Lapointe
University of British Columbia

This paper reports results of an exploratory study examining factors that might be associated with achievement in mathematics and participation in advanced mathematics courses in Canada, Norway, and the United States of America (USA). These factors, which were not directly related to schooling accounted for large degrees of variability, 24% to 39%, in mathematics achievement scores. Confidence in mathematics was the strongest predictor of achievement for students from Canada and Norway, whereas for the students from the USA, parents' highest education level was the highest predictor of achievement. Student home environment related variables were stronger predictors of achievement for females than for males in all three countries. The participation in advanced mathematics courses could be predicted with 72% to 76% accuracy by the same variables. In all of the three countries, the strongest predictors of participation in advanced mathematics courses were students' attitudes toward mathematics. Parents' education level, a socioeconomic related variable, was one of the strongest predictors of participation for Canadian female students and all students from the USA.

Even though gender differences in mathematics education seem to be narrowing in many countries, males tend to perform higher on mathematics achievement tests and tend to take advanced level mathematics courses in secondary schools more frequently than females do (Mullis & Stemler, 2002). In fact, previous research has shown that as students get older, gender differences favoring males increase in mathematics achievement (Campbell, 1995; Gray, 1996; Mullis, Martin, Fierros, Goldberg, & Stemler, 2000).

The Third International Mathematics and Science Study (TIMSS) is an international assessment that included assessment of mathematics achievement and participation in advanced mathematics courses in 45 countries. The results from this study indicated that gender differences in mathematics achievement were relatively minor for students at the primary and middle school years (Beaton et al., 1996; Mullis et al., 1997). However, in the final year of secondary school, achievement differences in mathematics between gender groups were found in every country except in South Africa. In other research, women comprised only 35% of the total number of graduates in the mathematical sciences in Britain in the early 1990s (Walkerdine, 1998).

Furthermore, in 1986 in Germany, half as many girls as boys were enrolled in mathematics and in chemistry, while in physics there was only one girl for every eight boys enrolled (Heller & Ziegler, 1996). Similar trends have been noted for the USA, Wales, England, and Scotland (Walkerdine, 1998). Conversely, in an interesting deviation from expected trends, in Latin and Latin-American countries, as well as in the Caribbean and Scandinavia, a higher proportion of women are participating in mathematics and in science occupations (Walkerdine, 1998). The results demonstrate that gender differences in achievement and participation levels in mathematics display different patterns in different countries.

In an effort to understand factors associated with mathematics learning, researchers have focused on many factors that include student attitude and background, curriculum and instruction, home environment, peer environment, teacher practices, and socioeconomic status (Beaton & Dwyer, 2002; Kellaghan & Madaus, 2002; Kifer, 2002; Wilkins, Zembylas, & Travers, 2002). Walberg (1981, 1984, 1992) identified nine factors that relate educational productivity to students' affective, behavioral, and cognitive developments. These factors were classified into three general groups by Wilkins et al. (2002): (a) personal variables, such as prior achievement, age, and motivation or self-concept; (b) instructional variables, such as amount or quality of instruction; and (c) environmental variables related to the home, teacher/ classroom, peers, and media exposure. These variables were identified as related to student achievement consistently in numerous studies (Reynolds & Walberg, 1991; Tsai & Walberg, 1983; Young, Reynolds, & Walberg, 1996; Walberg, 1984, 1992).

Although the second set of variables related to instruction are factors expected to be most directly related to learning, previous research has established that factors not related directly to curriculum and instruction can account for significant variability in mathematics participation and achievement (Catsambis, 1995; Eccles & Jacobs, 1986; Haggerty, 1991; Ho et al., 2000). Previous research also suggests that gender differences in the aforementioned variables become more pronounced as students move through the school years and are greatest by the end of high school (Ma & Kishor, 1997; Schibeci, 1984). Therefore, these variables present themselves as one of the reasons for greater achievement differences for gender groups by the end of secondary school.

The present study focused on exploring potential reasons for gender differences in mathematics achievement and participation in advanced level mathematics courses. Differential association between personal and environmental variables and achievement and participation in mathematics for gender groups was examined in three countries. These countries were selected because of their differential patterns of gender differences from lower grades to higher grades. All three countries had significant gender differences in achievement at the end of secondary school. One of the countries, Norway, was a country with one of the smallest differences in mathematics achievement in elementary and middle school levels yet had one of the largest differences in mathematics achievement between males and females by the end of secondary school. The two other countries, Canada and the USA, both had small gender differences in achievement at the lower grades. By the end of secondary school, students in Canada had moderate level differences between gender groups, whereas, in the USA differences in achievement levels for the gender groups were small.

These differential patterns of gender differences can provide opportunities to examine how different factors might be affecting males' and females' achievement and participation in mathematics. Differences in these associations can be informative regarding how differences in achievement and participation may develop as students get older. For example, different levels of association between these variables and mathematics for countries with large gender differences in mathematics may indicate increasing levels of association between these variables and mathematics achievement and participation as children get older. Specific research questions the study addressed can be summarized as follows:

1. How are the personal and environmental variables associated with achievement in mathematics for females and males in the three countries, Canada, Norway, and the USA?

2. How are the personal and environmental variables associated with participation in advanced mathematics courses for females and males in the three countries, Canada, Norway, and the USA?

Method

Data

The 1995 TIMSS provides information on the mathematics and science participation and achievement of students from over 40 different nationalities (Martin & Kelly, 1996). Even though more recent international assessments of achievement have been conducted, TIMSS was the latest international survey of achievement that included students from the final year of their secondary education.

Although TIMSS collected data from students in their final year of study in secondary schools in 21 countries, the study focused on data from three countries that had differential gender difference patterns from lower to upper grades, as discussed in the previous section. These countries were Canada, Norway, and the United States of America. The data were representative of their respective populations of senior secondary school students from these countries with large sample sizes (Canada: $n = 5{,}232$; Norway: $n = 2{,}518$; USA: $n = 5{,}807$).

Three tests were administered to these students: (a) a mathematics and science literacy test, which all students were eligible to complete; (b) a physics test, which only students enrolled in advanced physics courses were eligible to complete; and (c) an advanced mathematics test, which only students enrolled in advanced mathematics courses were eligible to complete. This study focused on the sample of students who completed the mathematics literacy test, some of whom also took the advanced mathematics test.

In addition to achievement tests, students were required to complete background questionnaires. Information collected in these questionnaires included (a) students' participation in advanced mathematics and science courses; (b) students' beliefs and attitudes toward mathematics and science; (c) students' self-expectations and their perceived expectations of others in terms of attending university; and (d) students' home environment. Data from these questionnaires were used to explore the potential associations between mathematics achievement and participation and student personal and environmental variables.

Analyses

The relationships between two dependent variables (students' mathematics achievement and participation in advanced mathematics courses) and various independent variables that included both student personal and environmental variables (students' attitudes toward mathematics; parents' highest level of education attained; self-expectations and the expectations of parents, teachers, and friends; students' confidence in mathematics; home support for learning; and whether students intended to pursue studies in mathematics) were investigated. Two statistical methods that are used for exploratory analyses of multivariate associations were determined to be appropriate for the analyses.

Multivariate regression analysis provides information about the relationship between an interval dependent variable and a set of independent variables. This information includes the degree to which variation in the dependent variable is explained by the independent variables as a set, as well as providing information about whether each of the independent variables has a statistically significant association with the independent variable. When the dependent variable is categorical, similar kinds of information can be obtained using the discriminant function analysis. In this study, multiple regression analyses were performed to investigate the relationship between mathematics achievement and the various independent variables by gender and by country.

Discriminant function analyses were performed to examine the relationship between participation in advanced mathematics courses and the same independent variables – also by gender and by country. All the analyses utilized the sampling weights provided in the TIMSS databases, in order for each sample to be representative.

Multiple regression analyses. The multiple regression analyses addressed the first research question: How are the personal and environmental variables associated with achievement in mathematics for females and males, in the three countries, Canada, Norway, and the USA? The regression analyses were performed in three stages. The first included a dummy variable called "Country" (student's country) as an independent variable. If the regression results indicated that this variable was a significant predictor of mathematics achievement in the model, then the remaining regression analyses would be completed separately by country (i.e., if a student's country could be used to predict achievement scores in mathematics, then it is more appropriate to examine models at a country level, rather than across countries). For these reasons, a second set of multiple regression analyses would be completed separately by country, where gender would be entered as a dummy variable in the model. If the results indicated that gender was a significant predictor of mathematics achievement in the model, then the remaining regression analyses would be completed separately by gender.

Examination of regression analyses results for each group focused on comparisons of standardized β coefficients across the independent variables. Comparisons of coefficients across the independent variables provide information about the relative strength of the relationship between the dependent variable and each of the independent variables. For example, comparison of the relative strength of the relationship between achievement and confidence in mathematics, and the relationship between achievement and home support for learning can provide information about whether students' confidence in mathematics accounts for a higher variation in achievement than does home support for learning. The respective dependent and independent variables included in the regression analyses follow.

Dependent variable. Students' mathematics literacy scores were identified as the dependent variable. TIMSS uses a matrix sampling design, in which students are administered booklets that contain samples of test questions. Therefore, students are not administered all the test questions. A statistical estimation procedure is used to adjust for the low reliabilities of scores obtained from the short tests the students are administered (Gonzalez, Smith, & Sibberns, 1998). Individual students are assigned five plausible values that provide an estimate of students' mathematics literacy if each examinee were administered all of the mathematics test questions. Even though for some analyses, using each plausible value separately and taking an average of the analyses results are recommended, it would not be appropriate in this case. Taking averages of the standardized β values or $R^2_{-adjusted}$, the key results of the regression analyses used in this study would not be meaningful. In the current study the first plausible values reported for each student were used .

Independent variables. A set of questionnaire items that were determined to be related to student personal and environmental variables were used in the study as independent variables. Attitudes and home support for learning were measured by a set of questions with ordinal responses. In regression and discriminant function analyses it is preferable to combine variables that are expected to have high correlations into one scale in order to avoid effects due to multicollinearity (Tabachnick & Fidell, 2001). When variables are assessed on an interval scale, methods such as principal components analysis may be used to create scores that combine responses from a group of questions. Conversely, when question responses are ordinal, factor analysis-based methods are not appropriate to use.

In this study, nonlinear principal components analyses were implemented (as described by Gifi, 1990) to combine ordinal responses and questions measuring attitudes and home support for learning. The resulting scores were expected to have a mean of 0 and a standard deviation of 1. Six independent variables, some of which were composites and others of which were individual variables based on a single questionnaire question, were used. A description of each independent variable follows:

1. Students' overall attitudes toward mathematics: Four-point ordinal responses to the following items were combined using nonlinear principal components analysis: (a) Mathematics is boring; (b) Mathematics is an easy subject; (c) I would like a job that involves using mathematics; and (d) How much do you like mathematics?

2. Parents' highest level of education attained: Each student reported her or his mother's and father's highest education level attained, according to a 6-point scale (ranging from finishing primary school to graduation from university). Students' individual responses were then recoded into one of three categories of parents' education level: (a) highest level attained was graduation from university; (b) highest level attained was graduation from secondary school; and (c) highest level attained was finishing primary school.

3. Students' and others' expectations regarding higher education: Students were asked to indicate whether they perceived that they would attend university full time after graduating from secondary school. They were also asked to report on their perceptions of their mothers', fathers', teachers', and friends' respective expectations of the students regarding attending university full time. The response categories were Yes or No.

4. Home support for learning: Ordinal responses to the following items were combined using a nonlinear principal components analysis, and the combined scale was interpreted as "home support for learning": (a) the number of books students had at home; (b) whether or not the students owned calculators at home; and (c) whether or not the students had computers at home.

5. Confidence in mathematics: Four-point ordinal responses to the following items were combined using a nonlinear principal components analysis to measure student perceptions of their self-confidence in mathematics: (a) Mathematics is easy; and (b) I am good in mathematics.

6. Intention to study mathematics or science: Students were asked to indicate which of 11 programs they would most like to study after graduation from secondary school: (a) biology science; (b) business; (c) chemistry; (d) computer science; (e) earth sciences; (f) engineering; (g) health occupations; (h) health science; (i) mathematics; (j) physics; and (k) other. Students' responses were then recoded into two categories: (a) the student intends to study in a mathematics- or science-related field if the student responded positively to any one of the first 10 programs; and (b) the student intends to study in an area outside of mathematics or science if the student responded positively to the last program (other).

Discriminant Function Analyses and Mathematics Participation

The discriminant function analyses addressed the second research question: How are the personal and environmental variables associated with participation in advanced mathematics courses for females and males in the three countries, Canada, Norway, and the USA? The dependent variable was students' responses to whether or not they have taken advanced mathematics courses. The independent variables were the same as those used in the multiple regression analyses.

Results

Gender Differences in Mathematics Achievement

Table 1 displays the mean and standard deviation of the mathematics literacy scores separately by gender and by country. There were significant differences between males and females in all three countries, as was reported in other TIMSS publications. The largest difference between gender groups was found among

Table 1
Descriptive Statistics for Mathematics Literacy Score by Country and by Gender

	Total	Female	Male	Difference
Canada				
Mean	520	504	538	-34*
SD	90	86	91	
N	5,205	2,533	2,672	
Norway				
Mean	529	501	556	-55*
SD	94	83	96	
N	2,518	1,328	1,190	
USA				
Mean	462	457	467	-10*
SD	90	87	94	
N	5,807	2,968	2,839	

*$p < .001$

Norwegian students, while the smallest gender differences were found among American students. The mean difference between the Norway gender groups was more than half of 1 standard deviation of the combined sample.

Gender Differences in Participation Rates

The participation rates in advanced mathematics courses are presented in Table 2 by gender and by country. Large differences were observed in the participation rates of males and females in Canada and in Norway. In all three countries, males showed higher participation rates in mathematics than females, though this difference was small in the USA sample.

Multiple Regression Analyses

The multiple regression analyses focused on determining how the independent variables related to personal and environmental variables varied in their associations with achievement in mathematics for males and females in the three countries. The statistical significance of this variation was tested by using country membership as a dummy variable. The results indicated significant differences for the countries (F (12, 1325) = 60.10, $p < .001$). This finding suggested that the relationship between the dependent variables and the independent variable, mathematics achievement, was different for the three countries. Further, regression analysis—which tested the significance of gender differences in the regression model—indicated that there were significant differences between the gender groups within each country: Canada, $F(11, 242839) = 9702.38, p < .001$; Norway, $F(11, 38416) = 2414.76, p < .001$; USA, $F(11, 1943850) = 105352.00$, $p < .001$. This finding indicated that there were differential associations between the independent variables and the mathematics achievement for males and females. The results of separate multiple regression analyses for males and for females within each of the three countries are presented in Table 3.

Table 2
Percentage of Students Participating in Advanced Mathematics Courses by Country and by Gender

	Total	Female	Male
Canada	24	20	28
Norway	15	10	20
USA	24	24	25

The variance in the mathematics achievement scores for which the regression models accounted ranged from 24% (for Canadian females) to 39% (American females). In the USA and in the Norway samples, the percentage of variance accounted for by the model was similar for females and for males (USA: 39% and 36%, respectively; Norway: 35% and 34%, respectively). The largest difference, 10%, was observed between Canadian females and males, indicating that the personal and home environment related independent variables accounted for a larger amount of variance in the mathematics achievement scores for males than females.

Standardized β-coefficients were used to examine the strength of each independent variable as a predictor. Almost all of the independent variables were identified to be statistically significant. However, when the sample size is large, even the independent variables with weak associations with the dependent variables may be significant. Therefore, independent variables with standardized β-coefficients greater than 0.1 were considered to be strong predictors. Confidence in mathematics, a self-concept related variable, was the strongest predictor of mathematics achievement for females and for males in all three countries, except for American females. The strongest predictor for American females was parents' highest level of education attained (although confidence in mathematics placed second). In Canada, confidence in mathematics was a stronger predictor for males than for females, while the converse was true for Norwegian students.

Table 3
Standardized Beta Coefficients From Multiple Regression Analyses of Mathematics Achievement

Independent Variables	Canada		Norway		USA	
	Female	Male	Female	Male	Female	Male
Attitude towards mathematics	.10*	.07*	**.19***	**.26***	**.19***	.09*
Confidence in mathematics	**.22***	**.30***	**.33***	**.25***	**.20***	**.21***
Fathers' expectations	.01*	.09*	.02*	.06	.01*	.13*
Mothers' expectations	.00	.03*	.00	.02	.01*	.03*
Friends' expectations	**.13***	**.11***	.09*	.04*	**.13***	.04*
Self expectations	**.11***	**.14***	**.13***	**.19***	**.14***	**.16***
Teachers' expectations	.05*	.06*	.01*	.07	.02*	.07*
Area student intends to study	.07*	.08*	.04*	.03*	.05*	.00*
Home support for learning	**.19***	.09*	.10*	.06*	**.16***	**.15***
Parents' highest education level	.10*	.08*	.10*	.03*	**.25***	**.19***
R^2	.24	.34	.35	.35	.39	.36
R^2-Adjusted	.24	.34	.35	.34	.39	.36

$*p < .01$.
Note. Coefficients greater than 0.1 are in bold.

Among American students, the strength was similar for both gender groups.

Among American females and Norwegians, a self-concept related variable, attitude toward mathematics, was another strong predictor of mathematics achievement but was not for either Canadian gender group or among the American males. Home support for learning and parents' highest education level, two environment related variables, were strong predictors of mathematics achievement for Canadian females and for Americans of both genders. These variables were not strong predictors of achievement for Canadian males and for students in Norway. Another strong predictor of mathematics achievement was students' self-expectations regarding attending university, but was more strongly associated with achievement among males than females regardless of country.

Discriminant Function Analysis

The results for the discriminant function analyses by gender and country are presented in Table 4. This table presents the correlations between each of the independent variables and the discriminant functions. Interpretation of correlations is similar to those of loadings in a factor analysis. Correlations are preferred over discriminant function coefficients for interpretation due to their stability. Correlations equal to or greater than 0.5 were interpreted as indicating strong association with participation in advanced mathematics courses. The last row in the table displays the accuracy of classification of examinees based on the discriminant functions. These percentages of classification accuracy indicate the degree of accuracy of predictions of participation of students in advanced level science courses using the independent variables and the strength of the relationship between independent variables as a set and the dependent variable.

Among Canadian students, the participation prediction accuracies for mathematics were higher for females than for males (74% versus 72%, respectively), indicating that the model could classify participation in mathematics more accurately for females than for males. For both gender groups, mathematics confidence and attitude toward mathematics were the strongest predictors of participation for both gender groups, and for females, parents' highest education level attained was also among the strongest predictors.

Among American students, participation prediction accuracies for mathematics were higher for males than for females (75% versus 72%, respectively). While friends' expectations and self-expectations were both strong predictors of participation for males, attitude toward mathematics was the strongest predictor for females.

Among Norwegians, participation prediction accuracies for mathematics were higher for females than for males (76% versus 72%, respectively). For both gender groups, attitude toward mathematics was the strongest predictor of participation.

Table 4
Discriminant Function Analysis Results for Participation in Advanced Mathematics Courses — Correlations With the Discriminant Function

	Canada		Norway		USA	
	Female	Male	Female	Male	Female	Male
Attitude toward mathematics	**.69**	**.65**	**.70**	**.72**	**.63**	**.53**
Confidence in mathematics	**.67**	**.65**	.33	.44	**.52**	**.54**
Fathers' expectations	.34	.40	.28	.35	.48	**.53**
Mothers' expectations	.39	.42	.30	.33	**.52**	**.53**
Friends' expectations	.36	.46	.25	.30	**.54**	**.62**
Self expectations	.36	.43	.40	**.59**	**.51**	**.63**
Teachers' expectations	.29	.35	.16	.29	.38	.48
Area student intends to study	**.57**	**.59**	.38	.21	.10	.20
Home support for learning	.21	.21	.24	.31	.38	.32
Highest parent education level	**.67**	.24	.46	.37	**.50**	**.56**
Accuracy of Classification	74%	72%	76%	73%	72%	75%

Note. Correlations equal or greater than 0.5 are in bold.

Summary and Discussion

Personal and home environment related variables were determined to be strongly associated with mathematics achievement and participation in advanced mathematics courses consistently for all groups. One of the purposes of international assessments is to examine educational systems and practices and their effects on learning and achievement. High levels of association between the variables considered in this study and mathematics achievement highlight the importance of these variables and point to the limitations of focusing on schooling only (for example curriculum and instruction) in understanding factors associated with learning. In particular, consistency of such high levels of associations between these variables in the three countries indicate that the variables not directly related to schooling have strong associations with learning independent of educational system and culture.

Some differences across countries and gender groups were observed in the strength of the relationship between each of the independent variables and mathematics achievement. The most noticeable country difference was in the relationship between home environment related variables, home support for learning and parents' highest education level, and mathematics achievement. These variables were strongly associated with mathematics achievement for the female and male USA students and female Canadian students. The home environment variables considered in this study are expected to be related to students' socioeconomic status. The results indicate that socioeconomic status was associated with mathematics achievement at a stronger level for the USA students, and the Canadian female students.

Within each country, there were distinct differences between gender groups regarding strength of predictors for achievement. Among Canadian students, there was 10% difference in the variability in achievement scores accounted for by the regression model, with the model accounting for a larger percent of variability for males than for females. This points to the possibility that Canadian female students have a stronger relationship between other variables that were not considered in this study (such as curriculum and instruction and mathematics achievement) than did Canadian male students. In addition, home environment related variables were stronger predictors of achievement for females than for males in all three countries. This result highlights the possibility that in all three countries, females in lower socioeconomic backgrounds may be more severely disadvantaged than are males from the same socioeconomic background levels.

Among American students, though attitude toward mathematics was one of the strongest predictors for females, this self-related variable was not a strong predictor of achievement for males. This result indicates that, though American female students who had positive attitudes tended to have higher achievement scores, such a relationship was much weaker for American male students. Instead, father's expectations regarding higher education was a stronger predictor for American males.

The degree of association between the personal and home environment related variables and participation in advanced level mathematics courses was similar across the three countries. The participation in advanced mathematics courses could be predicted by these variables with 72% to 76% accuracy in all three countries. The results indicate strong levels of association between these variables and participation in advanced level mathematics courses.

One of the important factors in students' decisions regarding taking advanced mathematics courses is expected to be their plans regarding higher education. Even though such expectations were moderately associated with participation in advanced mathematics courses, these associations were not as strong as self-related variables, except for the male students from Norway and all the students from the USA. These students had a strong association between expectations regarding higher education and participation. In all three countries, strongest predictors of participation in advanced mathematics courses were students' attitudes toward mathematics.

The area a student intends to study in higher education is another factor that is expected to have a strong association with participation in advanced mathematics courses. However, this variable was only strongly associated with participation for the Canadian students. This difference for Canadian students may be related to the university entrance requirements in Canada, which require students to have taken advanced mathematics courses and passed a high school exit exam in advanced mathematics courses if they are interested in pursuing a mathematics- or science-related study in higher education.

Other evidence supports the notion that some of the differences among the three countries may be due, in fact, to university entrance requirements. For example, participation in advanced mathematics courses was considerably more strongly associated with whether students liked mathematics or not in Norway than in the other two countries. This result indicates that in Norway, students were highly unlikely to take advanced mathematics courses if they did not have positive attitudes toward mathematics. However, in Canada and the USA students with similar attitudes were more likely to take advanced mathematics courses.

Similar to mathematics achievement, parent's education level was one of the strongest predictors of participation for Canadian female students and all the students from the USA. This strong association between a socioeconomic status related variable and participation in advanced mathematics courses indicate that socioeconomic background is just as important a factor as their attitudes toward and confidence in mathematics as these students' participation in advanced mathematics courses. Such a finding indicates that gender differences in participation in advanced level mathematics courses for the Canadian students is not expected to be uniform across socioeconomic levels and, in fact, differential factors that affect gender differences might be at play for the different socioeconomic groups in Canada. In the USA, on the other hand, there is a small difference in participation rates of gender groups in advanced mathematics courses. However, the results point to different participation rates across different socioeconomic groups in this country.

Conclusion

The findings in this study provide consistent evidence that student personal and home environment variables are strongly associated with mathematics achievement and participation in advanced mathematics courses in all three countries. This finding supports previous research findings that identified strong associations between these variables and mathematics achievement and participation (Campbell, 1995; Gray, 1996; Mullis et al., 2000; Mullis & Stemler, 2002; Walkerdine, 1998). In order to teach mathematics to all children, personal and home environment related variables and how they affect mathematics learning and participation need to be taken into account. However, the way in which to take such associations into account in teaching mathematics is not an easy matter. First, the associations identified in this research are correlational and they are not causal. Therefore, the complex set of factors that might be the sources of associations are not known. Yet consistent evidence based on representative samples from three countries and other similar studies make a strong case for further investigating the associations identified in this research. In order to determine the practical implications of the findings here, in-depth studies investigating how personal and home environment factors might be affecting learning and participation are needed. In particular, educators need to know how students develop positive and negative attitudes toward mathematics, what the role of home environment on the development of these attitudes is, and how these attitudes affect motivation for learning mathematics and participating in advanced level mathematics courses.

Nevertheless, there is a great deal of evidence to confirm the relationship between attitudes toward mathematics learning and participation, even though our understanding of how this association develops and maintained is limited. This research strongly suggests that teaching of mathematics should be complemented with demonstrating importance, empowering students who might have received negative messages about mathematics learning (at best, who have not received positive messages) and showing relevance to other academic and personal goals.

The comparison of educational outcomes for students from different socioeconomic backgrounds has been done by researchers concerned about equity and educational outcomes (Fuller & Clarke, 1994; Willms & Paterson, 1995; Willms & Sommer, 2001; Wöbmann, 2000). This study confirmed the higher levels of associations between socioeconomic status related variables and educational outcomes in the USA found in previous research and, in addition, identified differential associations between educational outcomes and socioeconomic status for gender groups. The implication of this finding is that focusing on curriculum and instruction is not sufficient if social equity is a consideration in mathematics education.

A much greater degree of association between the socioeconomic status related variables and mathematics achievement for the USA indicates that socioeconomic status is not similarly associated with achievement in different countries. This result can be interpreted in two ways. One is that the meaning of socioeconomic background and its impact on mathematics achievement is different in different countries. The second interpretation is that schooling is more successful in creating equity among students from different backgrounds. Using either interpretation leaves a great degree of responsibility to mathematics educators in the USA to understand how the disadvantage associated with coming from a lower socioeconomic background affects learning and identifying processes in schooling that can counter such disadvantages.

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Editors' Note: Correspondence concerning this article should be addressed to Kadriye Ercikan, Educational and Counselling Psychology and Special Education, Faculty of Education, 2125 Main Mall, University of British Columbia, Vancouver, BC, Canada V6T 1Z4.

Electronic mail may be sent via Internet to kadriye.ercikan@ubc.ca