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AN EXPLORATION OF THE MATHEMATICS SELF-EFFICACY/MATHEMATICS PERFORMANCE CORRESPONDENCE

GAIL HACKETT, *Arizona State University*
NANCY E. BETZ, *Ohio State University*

This study investigated the relationship between mathematical performance and mathematics self-efficacy, attitudes toward mathematics, and the choice of mathematics-related majors by 153 college women and 109 college men. Mathematics performance was correlated moderately with mathematics self-efficacy. No support was found for Hackett and Betz's (1981) hypothesis that women's mathematics self-efficacy expectations are *unrealistically* low compared to men's. Both mathematics performance and mathematics self-efficacy were significantly and positively correlated with attitudes toward mathematics, masculine sex-role orientation, and a mathematics-related major. Regression analyses supported the superiority of mathematics self-efficacy over mathematics performance and achievement variables in predicting the choice of a mathematics-related major.

A new and particularly rich avenue of inquiry into educational attainment and ultimately into career development has been opened by the self-efficacy perspective on achievement behavior (Schunk, 1984, 1985) and applications of Bandura's (1977, 1982) self-efficacy theory to the understanding of vocational behavior, particularly the career behavior of women (e.g., Betz & Hackett, 1983; Hackett, 1985; Hackett & Betz, 1981; Lent, Brown, & Larkin, 1984).

Bandura (1977) postulates that self-efficacy expectations, that is, a person's beliefs concerning his or her ability to successfully perform a given task or behavior, are a major determinant of whether a person will attempt a given task, how much effort will be expended, and how much persistence will be displayed in pursuing the task in the face of obstacles. According to self-efficacy theory, perceived self-efficacy influences, and is in turn influenced by, thought patterns, affective arousal, and choice behavior as well as task performance (Bandura, 1986).

Hackett and Betz (1981), in extending Bandura's (1977) theory to the domain of career behavior, have pointed out the importance of the construct of self-efficacy in understanding the differences in the educational and career choices of women and men. They argue that, largely as a result of socialization experiences, women exhibit lower expectations than men for many achievement-related behaviors and thus fail to fully realize their capabilities and talents in career pursuits.

A topic of great interest to researchers examining applications of self-efficacy theory to educational attainment and career development is the relation of mathematics performance to mathematics self-efficacy (Betz & Hackett, 1983; Hackett, 1985). Women's continued underrepresentation in the relatively higher paying, higher status, scientific and technical fields has been partially explained by their lack of preparation, relative to men, in mathematics (Goldman & Hewitt, 1976; Sells, 1980; Sherman, 1982). Female students take significantly fewer mathematics courses than male students do in both high school and college, and fewer women than men elect to major in mathematics (Ernest, 1976; Hewitt & Goldman, 1975). These sex differences in mathematics avoidance have, in turn, been thought to result from socialized negative attitudes and affective reactions to mathematics, such as mathematics anxiety (Betz, 1978; Eccles & Jacobs, 1986; Fennema & Sherman, 1977, 1978; Hendel, 1980; Sherman & Fennema, 1977). From the perspective of social learning theory, however, self-efficacy expectations are proposed to be an even more important factor influencing attitudes toward mathematics and mathematics performance as well as mathematics-related educational and career choices (Bandura, 1977, 1982: Hackett & Betz, 1981).

Mathematics self-efficacy can be distinguished from other measures of attitudes toward mathematics in that mathematics self-efficacy is a situational or problem-specific assessment of an individual's confidence in her or his ability to successfully perform or accomplish a particular task or problem. Fennema & Sherman's (1976) *confidence in learning mathematics,* a seemingly similar concept, in fact addresses a more generalized or global confidence in one's ability to learn mathematics. Because of its behavioral and situational specificity, Bandura (1986) considers self-efficacy to be more predictive of future performance than such global indicators as confidence in learning mathematics. Further, mathematics anxiety is viewed, according to social learning theory, as a result of low mathematics self-efficacy. Thus, mathematics anxiety should be related to mathematics self-efficacy, but mathematics self-efficacy is considered the more important predictor of future mathematics-related performance, and a predictor of mathematics anxiety as well.

Preliminary studies on mathematics self-efficacy (Betz & Hackett, 1983; Hackett, 1985) support the major mediational role of self-efficacy expectations in the process of choosing a mathematics-related career. Results from these studies indicate that mathematics self-efficacy is significantly correlated both with attitudes toward mathematics and with the extent to which college students select mathematics-related college majors. Furthermore, the mathematics self-efficacy of men was found to be significantly stronger than that of women. And finally, the incremental utility of mathematics self-efficacy over certain other performance and mathematics attitudes variables has been demonstrated. Hackett (1985) reported the results of a path analysis indicating that mathematics self-efficacy contributed more significantly than sex, years of high school mathematics, ACT mathematics score, or mathematics anxiety to predicting the choice of a mathematics-related college major.

Another group of researchers, Siegel, Galassi, and Ware (1985), in a comparison of alternate explanatory models of mathematics performance, found the self-efficacy model superior to a mathematics aptitude/mathematics anxiety model in predicting college students' performance on a mathematics exam. In their study, the combined predictors of SAT mathematics score, incentives, and mathematics self-efficacy accounted for a much higher percentage of the variance in mathematics exam scores than the combined effects of SAT mathematics score, mathematics anxiety, sex, and sex role. Thus, researchers are beginning to test the robustness of alternate constructs used in understanding mathematics performance and mathematics-related educational decisions. Testing of the construct of mathematics self-efficacy, while promising, has only begun; more research is necessary in order to determine whether the construct's potential as a potent explanatory variable in mathematics education will be fully realized.

The purpose of the present study, then, was to extend the work already begun in researching mathematics self-efficacy, and specifically to explore microscopically the self-efficacy/performance correspondence, a currently unexamined area of study. Therefore, the major hypotheses of this study were as follows:

1. Self-efficacy with regard to specific mathematics problems will be related to actual performance on an equivalent set of problems. Theoretical predictions about the self-efficacy/performance correspondence have been confirmed at a global level, that is, general mathematics self-efficacy has been found to be strongly related to the ACT mathematics achievement scores (Hackett, 1985). However, this self-efficacy/performance relationship has not been evaluated at a more task-specific level.
2. The mathematics self-efficacy/mathematics performance correspondence will be stronger for men than for women. That is, women's self-efficacy expectations will be unrealistically low compared to men's (Hackett & Betz, 1981).

The secondary goals of the study were to examine the relationships among attitudes toward mathematics, mathematics self-efficacy, and mathematics performance, and to compare the incremental utility of mathematics self-efficacy with that of mathematics performance in predicting educational choices.

METHOD

Subjects

All subjects (153 women; 109 men) were undergraduate students enrolled in introductory psychology courses at a large midwestern university. Participation in the study was voluntary, and the subjects received course credit for their participation.

Instruments

Background and Career-Plans Questionnaire. This brief questionnaire contained a series of questions eliciting demographic information as well as information about mathematics preparation and career plans. Three variables—sex, the number of years of high school mathematics, and the mathematics-relatedness of students' declared college majors—were employed in the analyses. The students' preferences for a college major were classified according to Goldman and Hewitt's (1976) science-nonscience continuum. Scores on this continuum range from 1 to 5, with higher scores indicating greater emphasis on science and mathematics; scores of 1, for example, are associated with majors such as art or theater, whereas scores of 5 describe majors in the physical sciences, engineering, and mathematics.

Mathematics Self-Efficacy Scale (MSES). The Mathematics Self-Efficacy Scale, developed by Betz and Hackett (1983), contains 52 items identified as relevant to the study of mathematics-related self-efficacy expectations. The scale is composed of three subscales: (a) the Mathematics Tasks subscale, consisting of 18 items involving "everyday" mathematics tasks, e.g., balancing a checkbook; (b) the Mathematics Courses subscale, consisting of 16 mathematics-related college courses; and (c) the Mathematics Problems subscale, consisting of 18 arithmetic, algebra, and geometry problems, adapted from Dowling (1978).

For the courses subscale, the students were instructed to rate their confidence in their ability to complete each course with a grade of B or better. For the tasks and problems subscales, the students simply rated their confidence in their ability to successfully perform the task or solve the problem. Confidence ratings for all scales were elicited on a 10-point continuum from *no confidence at all* (0) to *complete confidence* (9). Mean scores were calculated for overall mathematics self-efficacy (total scale score) as well as for each subscale. Betz and Hackett (1983) reported moderate item-total score correlations for the MSES subscales and high internal-consistency reliabilities (coefficient alpha) for the three subscales (.90, .93, and .92, respectively, for the tasks, courses, and problems subscales) and the total 57-item scale (.96). A subsequent study (Hackett & O'Halloran, 1985) has demonstrated moderate test-retest reliabilities for the total scale (r = .88) and all three subscales (r = .79, .91, and .82, respectively, for the tasks, courses, and problems subscales).

Mathematics performance. Mathematics performance was measured by means of the Performance subscale of the Dowling (1978) Mathematics Confidence Scale. This scale consists of 18 items corresponding to the 18-item Mathematics Problems subscale of the MSES. The Mathematics Problems Performance Scale (MPPS) was developed so that assessments of confidence in mathematics problem solving could be directly compared to actual performance on similar, but not identical, problems. The specificity of this method of assessment is one of the distinguishing aspects of self-efficacy theory, in contrast to other approaches to assessing some variant of confidence in mathematics or "self-concept" with regard to mathematics. That is, self-efficacy theory calls for the assessment of confidence in performance expectations for specific tasks.

The MPPS can be divided into three nonorthogonal subscales characterizing the type of problem to be solved, the type of operation necessary to problem solving, and the level of abstraction of the problems. The Components scale consists of three subscales of 6 items each requiring solutions to arithmetic, algebra, and geometry problems; the Demand scale consists of three subscales of 6 problems each requiring computation, comprehension, or application; and the Context scale consists of two 9-item subscales consisting of real or abstract problems. Scores for all scales and subscales were determined by adding the number of correct responses and obtaining a mean score for each scale; thus, scores for all scales ranged from 0 to 1. Dowling (1978) presents information about the extensive pilot testing and subsequent refinement of this mathematics performance scale; she reported KR20 coefficients of reliability of .71 to .82 on alternate versions of the instrument.

American College Test (ACT) Mathematics Usage scores were obtained from university records as an additional index of mathematics performance and are hereafter referred to as *achievement* scores.

Fennema-Sherman Mathematics Attitude Scales. In order to examine the relationships of mathematics self-efficacy expectations and mathematics performance and achievement to the related construct of mathematics anxiety and to other attitudes toward mathematics, a revised version of the Fennema-Sherman Mathematics Attitude Scales (Fennema & Sherman, 1976) was used. The Fennema-Sherman scales, revised for use with college students (Betz, 1978), include five 10-item scales: Mathematics Anxiety, Confidence in Learning Mathematics, Perceptions of the Usefulness of Mathematics, Perceptions of Mathematics as a Male Domain, and Effectance Motivation in Mathematics. Responses to all 50 items are obtained on a 5-point scale ranging from 1 (strongly disagree) to 5 (strongly agree). Total scores may range from 10 to 50, with higher scores on all scales indicating more positive attitudes toward mathematics, for example, lower mathematics anxiety, less tendency to view mathematics as a primarily male domain, and greater tendency to view mathematics as useful. The scales are highly reliable, with KR20 values ranging from .86 to .90.

Bem Sex-Role Inventory (BSRI). In order to examine the relationship of sex-role variables to mathematics self-efficacy expectations and mathematics performance and achievement, the Bem Sex-Role Inventory (Bem, 1974) was used. The BSRI contains a Masculinity scale and a Femininity scale, each of which assesses 20 personality characteristics considered more socially desirable for males or females, respectively. Item responses are obtained on a 7-point scale in accordance with how well the person considers each characteristic to describe himself or herself; higher scores indicate greater descriptive accuracy. Total scores are the average of the 20-item responses obtained for each scale.

Procedure

The five instruments were administered to all subjects during one experimental session, then ACT scores were obtained from university records using the subjects' student ID number.

RESULTS

Relationship Between Self-Efficacy and Performance

In order to explore the relationship of mathematics self-efficacy to mathematics performance, all subscales of the MPPS and the corresponding subscales assessing self-efficacy with regard to mathematics problems were compared by means of Pearson product-moment correlations. The overall correlation coefficient between self-efficacy and performance was .44, indicating a moderately strong positive relationship, partially supporting the major hypotheses of the study. This overall correlation was positive but not as large as hypothesized. The correlation coefficients between subscale scores on the self-efficacy and performance scales ranged from .36 to .49. All correlation coefficients were significant at the .001 level.

Microanalysis of Self-Efficacy/Performance Correspondence

Although the preceding preliminary analysis offers important information about the relationship between mathematics self-efficacy and mathematics performance, the analysis was based upon mean scale and subscale scores. Bandura (1980) has made a strong case for gauging the degree of congruence between self-efficacy judgments and actions by examining that correspondence on individual tasks rather than on aggregate scores. Because of the differences in the tasks involved, it was not possible to analyze the data gathered in this study precisely as Bandura has analyzed the self-efficacy/action relationship in past research on animal phobias; however, it *was* possible to conduct a microanalysis by sex of the mathematics self-efficacy and mathematics performance relationship using a somewhat different procedure.

The microanalysis was accomplished by computing mathematics self-efficacy/performance deviation scores (D scores) by separately transforming scores on the mathematics self-efficacy and mathematics performance scales to standardized scores (z scores), and then subtracting the standardized performance scores from the standardized self-efficacy scores for comparable items. Mean D scores were calculated for each student; thus, these D-score means are an index of the average difference on each item between self-efficacy and performance with regard to mathematics problems.

The resulting D scores could range from -2.00 (indicating underconfidence in performance) through 0 (indicating congruence between self-efficacy and performance) to $+2.00$ (indicating overconfidence in performance). On the basis of previous research by Dowling (1978), D scores were classified into five categories: overconfident (D scores > 0.8), somewhat overconfident ($0.4 < D$ score ≤ 0.8), congruent ($0.4 \geq D$ score ≥ -0.4), somewhat underconfident ($-0.4 > D$ score ≥ -0.8), and underconfident (D score < -0.8). The percentage of men and women falling into each D-score category is presented in Table 1.

Overall, only 35% of the students had D scores in the congruent range. Forty-eight percent were in the overconfident range (somewhat overconfident or overconfident), and only 18% were in the underconfident range (somewhat underconfident or underconfident). For the women, 43% were classified as overconfident and 18% as underconfident, compared to 54% of the men classified as overconfident and 16% as underconfident. A chi-square analysis of the data in Table 1 did not indicate a significant relationship between sex and D-score category, $\chi^2(4, N = 262) = 3.86$, n.s. Thus, the mathematics self-efficacy/mathematics performance analyses lend support to the hypotheses of Bandura (1977) regarding the positive relationship between self-efficacy and performance, but do not support Hackett and Betz's (1981) proposition that women's mathematics self-efficacy expectations are *unrealistically* low when compared to their actual performance, at least for the subset of mathematics-related skill represented by the Mathematics Problems scales.

Mathematics Self-Efficacy, Performance, and Attitudes Toward Mathematics

Pearson product-moment correlations were computed between mathematics performance on the MPPS, mathematics achievement on the ACT, mathematics self-efficacy, and the same sex-role and mathematics attitudes variables employed in previous self-efficacy research in order to compare the strength of the relationships of self-efficacy, performance, and achievement to other variables that have been found to be predictive of mathematics-related career preferences and choices. Table 2 contains the results of these analyses.

Table 1
Frequency of Overconfidence and Underconfidence by Sex

D score category	Women (N = 153)		Men (N = 109)	
	n	%	*n*	%
Overconfident (above 0.8)	38	24.8	33	30.3
Somewhat overconfident (from 0.4 to 0.8)	28	18.3	26	23.9
Congruent (from −0.4 to +0.4)	59	38.6	32	29.4
Somewhat underconfident (from −0.8 to −0.4)	14	9.2	7	6.4
Underconfident (below −0.8)	14	9.2	11	10.1

Note. Categorizations are based on average deviation scores.

Table 2
Product-Moment Correlations of Mathematics Self-Efficacy and Mathematics Performance Scores With Mathematics Attitudes and Sex-Role Variables

	Self-efficacy				Performance	
Variable	Tasks (n = 262)	Courses (n = 262)	Problems (n = 262)	Total (n = 255)	Problems (n = 262)	Achievement[a] (n = 181)
			Attitude towards mathematics			
Mathematics anxiety	.40*	.61*	.43*	.56*	.40*	.45*
Mathematics confidence	.46*	.73*	.53*	.66*	.43*	.57*
Mathematics as a male domain	.03	.04	.08	.09	.04	.12
Usefulness of mathematics	.31*	.52*	.41*	.47*	.28*	.40*
Effectance motivation	.34*	.51*	.35*	.46*	.32*	.40*
			Sex role			
Masculinity	.28*	.29*	.23*	.33*	−.02	
Femininity	.01	.01	−.06	.00	−.08	

[a] Achievement = American College Test Mathematics Usage scores.
*$p < .01$.

Mathematics self-efficacy scale and subscale scores and the indices of mathematics performance and achievement were significantly correlated with four of the five revised Fennema-Sherman Mathematics Attitudes Scales. Only the Mathematics as a Male Domain scale was not significantly correlated with the mathematics self-efficacy or the mathematics performance or achievement variables. The Mathematics Courses subscale of the MSES yielded the highest correlations with the four mathematics attitudes scales for which significant values of r were found (r ranging from .51 to .73). Correlation coefficients between the total MSES score and the mathematics attitudes variables were slightly but consistently higher than correlations between mathematics attitudes and the achievement scores (r ranging from .40 to .57). The correlations between performance scores on the problems scale and scores on the mathematics attitudes scales were slightly lower than the achievement/attitude correlations.

The scores on the BSRI Femininity scale were not significantly correlated with any of the other variables; Masculinity scale scores were significantly and positively correlated with all self-efficacy scales, but not with the performance scores (Table 2).

These analyses indicate that students with high scores on mathematics self-efficacy and mathematics performance and achievement, compared with those with low scores, tend to report lower levels of mathematics anxiety, higher levels of confidence and effectance motivation, and a greater tendency to see mathematics as useful. In addition, stronger mathematics self-efficacy expectations, but not mathematics performance, are related to higher scores on the BSRI Masculinity scale but are unrelated to BSRI Femininity scores. Slightly stronger relationships exist between attitudes toward mathematics and mathematics self-efficacy expectations than between mathematics attitudes and mathematics performance and achievement measures.

Prediction Equations

Table 3 shows the results of a stepwise multiple regression analysis using the Goldman and Hewitt (1976) science-mathematics code of declared college major as the dependent variable. Of the independent variables employed in the analysis—mathematics problems performance, achievement, MSES score, sex, BSRI Masculinity score, years of high school mathematics, and Mathematics Anxiety score—only three contributed significantly to the prediction of the science-mathematics code of college-major choice. The male students reporting higher levels of mathematics self-efficacy and more years of high school mathematics were more likely to have selected mathematics-related college majors. Neither the mathematics performance nor the mathematics achievement variable entered significantly into the equation. The obtained multiple regression coefficient was $R = .60$; thus, the three significant predictors accounted for 34% of the variance in the prediction of the mathematics-relatedness of college-major choice.

Because mathematics self-efficacy and mathematics performance are correlated, an exploratory post hoc regression analysis was conducted in order to determine the additional contribution of mathematics self-efficacy to the prediction of mathematics-related college majors beyond that of the mathematics performance variables. A hierarchical regression analysis was run specifying that mathematics self-efficacy be entered *after* the mathematics problems and achievement scores. Table 4 presents the results of the three stages of this exploratory analysis.

Table 3
Stepwise Regression Analysis for the Prediction of Science-Nonscience College-Major Choice

Significant predictors	Beta	F	R	R^2 Adjusted
		21.00**	.60	.34
Mathematics self-efficacy expectation	.33	14.70**		
Sex	−.25	10.35*		
Years of high school mathematics	.23	7.00*		

Note. Sex was scored 0 for men, 1 for women. *df* for F values of beta weights were 1, 113; *df* for overall F value were 3, 113.
$^*p < .01$. $^{**}p < .001$.

Table 4
Hierarchical Regression Analysis for the Prediction of Science-Nonscience College-Major Choice

Predictor	Beta	F	R	R^2 Adjusted
	Regression 1			
		5.79*	.22	.04
Problems	.22	5.79		
	Regression 2			
		9.70**	.38	.13
Problems	−.005	0.002		
Achievement	.38	13.01***		
	Regression 3			
		13.04***	.51	.24
Problems	−.03	0.12		
Achievement	.11	0.78		
Mathematics self-efficacy	.45	16.98***		

Note. *df* for overall F values were 1, 115; 2, 114; and 3, 113 for Regressions 1, 2, and 3, respectively.
$^*p < .05$. $^{**}p < .01$. $^{***}p < .001$.

The results of the hierarchical regression analysis indicated that, even with the effects of the mathematics performance and achievement variables partialed out, mathematics self-efficacy expectations contributed significantly to the equation predicting college-major choice. In fact, when all three variables were included in the prediction equation, only mathematics self-efficacy contributed significantly. Thus, the mathematics performance and achievement variables added no predictive utility after mathematics self-efficacy expectations were taken into account, as indicated by the stepwise regression analysis, and they also did not contribute to the prediction of mathematics-relatedness of college-major choice even when their contribution was accounted for before the mathematics self-efficacy variable was introduced into the equation.

DISCUSSION

Findings emerged from the present study that cast doubt on experimental hypotheses about sex differences in the realism of mathematics self-efficacy expectations. When differences in the realism of self-efficacy were explored by comparing self-efficacy/performance deviation scores by sex, trends for men to be more often classified as overconfident and women to be more often classified as congruent or underconfident were suggested, but the differences did not reach statistical significance. These results suggest that to a great extent sex differences in mathematics self-efficacy expectations are correlated with sex differences in mathematical performance.

One of the most intriguing findings of this study was that the majority of students, male and female, inaccurately estimated their performance capabilities on this set of mathematics problems. Only a minority of students were classified in the congruent category, which indicated a small disparity between self-efficacy estimates and performance scores. The majority of men classified into one of the incongruent categories and a large minority of women classified as incongruent overestimated rather than underestimated their performance capabilities. This tendency on the part of all students toward inaccurate self-estimates of performance, coupled with the moderate correlations found between the self-efficacy and performance subscale scores, suggests that the judgment/action correspondence in mathematics performance is more complex and weaker than the judgment/action correspondence in other domains of achievement (cf. Bandura, 1986).

The hypothesis that mathematics-related self-efficacy expectations are stronger predictors of mathematics-related educational and career choices than mathematics performance or past mathematics achievement received support; the stepwise multiple regression analysis indicated that male students who reported higher mathematics-related self-efficacy expectations and more years of high school mathematics preparation were more likely to have declared a science-related college major. As in previous studies (Betz & Hackett, 1983; Hackett, 1985), mathematics self-efficacy was the strongest predictor of college-major choices; neither the measure of mathematics achievement nor the measure of mathematics performance entered the prediction equation. Bandura (1977, 1982) has hypothesized that self-efficacy is the central mediator of past experience and performance as well as being the major predictor of future performance. Therefore, the cognitive information tapped by the assessment of mathematics self-efficacy should, theoretically, encompass the information an individual has derived from his or her own past performance, making such achievement information as ACT scores redundant if one possesses information about self-efficacy. This hypothesis received support from the results of this study.

The post hoc hierarchical regression analysis provided additional, unexpected support for the crucial role of mathematics self-efficacy in the choice of a mathematics-related major. Surprisingly, only mathematics self-efficacy proved to be a significant predictor of the choice of a mathematics-related major even though the self-efficacy variable was entered into the equation after the mathematics performance and achievement variables. It was not surprising to find that the achievement variable was more predictive than the mathematics problems performance measure, given that the latter covered a narrower domain of mathematical behaviors. However, it was expected that there would be some unique contribution from the performance and achievement variables in predicting the choice of a mathematics-related major. The results of this regression analysis appear to provide support for the hypotheses that mathematics-related self-efficacy expectations contain the information provided by measures of mathematical performance and achievement and, furthermore, that they contribute additional predictive utility, at least with regard to the choice of a mathematics-related career. Further research using different and more generalizable measures of mathematical performance is necessary in order to replicate these results in other domains of mathematical performance.

IMPLICATIONS

Although statements about the exact nature of the mathematics self-efficacy/mathematics performance correspondence await further research, these results do have important implications for education. The importance of mathematics self-efficacy to the career choice process and the moderate relationship between self-efficacy and performance indicate that mathematics teachers should pay as much attention to self-evaluations of competence as to actual performance. In fact, cognitions concerning competence may be a much more critical factor than measured abilities in both educational and career choice processes, particularly for women pursuing nontraditional options. Furthermore, task- or situation-specific assessments of self-efficacy seem to yield different information than more global measures of performance self-esteem (Stake, 1979), confidence in learning mathematics (Fennema & Sherman, 1976), or mathematics self-concept (Eccles & Jacobs, 1986), and this information may be useful to teachers concerned with monitoring students' self-estimates of competence in mathematics.

Another important issue for educators is the hypothesized reciprocal relationship between self-efficacy and performance. According to Bandura (1977), past performance accomplishments inform currently held efficacy expectations, which in turn influence task initiation and persistence. Yet other sources of information affecting self-efficacy exist as well—for example, sex-role socialization messages from society, family, and classmates and teachers, discouraging women from achieving in traditionally masculine domains such as mathematics (Boswell, 1985; Eccles & Jacobs, 1986). It is therefore important for educators to assess not only the reality of self-efficacy expectations, particularly those of women and girls concerning nontraditional areas, but the possibility of modifying those cognitive self-evaluations.

In addition to past performance accomplishments, Bandura (1986) has hypothesized three major ways in which self-efficacy expectations can be modified: vicarious learning, for example, role models of achievement in mathematics, particularly female role models for girls; verbal persuasion such as encouragement, support, and information; and arousal reduction, for example, interventions specifically designed to decrease mathematics anxiety or test anxiety. All four sources of efficacy information are viewed as interacting complexly to influence self-efficacy, and effective interventions make use of a variety of ways in which to enhance self-efficacy and therefore enhance performance. Essentially, self-efficacy theory may be a heuristic model for mathematics teachers attempting to organize activities that supplement traditional classroom instruction in mathematics and promote both mathematics performance and realistic self-efficacy expectations in mathematics.

In conclusion, the concept of mathematics self-efficacy and its relationship to mathematics performance and achievement appears to have importance for both understanding and modifying the processes of educational and career decision making and enhancing mathematical achievement. Research in this area should shed light on the complex operations and interactions of the cognitive, attitudinal, affective, behavioral, familial, and social influences on women's and men's educational advancement and career involvement in mathematics. Further examinations of the mathematics self-efficacy/mathematics performance correspondence should also contribute to the development and refinement of causal models representing the complex influences on students' mathematics achievement and educational and career decision making (Eccles & Jacobs, 1986; Ethington & Wolfle, 1984; Hackett, 1985; Wise, 1979).

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AUTHORS

GAIL HACKETT, Associate Professor, Division of Psychology in Education, Arizona State University, Tempe, AZ 85287

NANCY E. BETZ, Professor, Department of Psychology, Ohio State University, Columbus, OH 43210