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ABSTRACT

The purposes of the present study were to develop and evaluate a measure of self-efficacy expectations with regard to the performance of mathematics-related behaviors and to investigate the relationship of mathematics self-efficacy expectations to the selection of science-based college majors. Based on results obtained from a pilot sample of 115 college students, 52 math-related tasks were selected from an initial 75-item pool. Subjects, 153 female and 109 male undergraduates, were asked to indicate their degree of confidence in their ability to successfully perform the tasks or problems or to complete the college course with a grade of "B" or better. As predicted, the mathematics-related self-efficacy expectations of college males were significantly stronger than were those of college females, particularly with regard to mathematics-related college courses. Mathematics self-efficacy expectations, but not any mathematics performance index, contributed significantly to the prediction of the degree to which students selected science-based college majors, thus supporting the postulated role of cognitive mediational factors in educational and career choice behavior. The utility of the concept and measure of mathematics self-efficacy expectations for the understanding and treatment of mathematics anxiety and mathematics-avoidant behaviors is discussed. (Author/MP)

Mathematics Self-Efficacy Expectations, Math Performance, and the Consideration of Math-Related Majors

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ABSTRACT

The purposes of the present study were to develop and evaluate a measure of self-efficacy expectations with regard to the performance of mathematics-related behaviors and to investigate the relationship of mathematics self-efficacy expectations to the selection of science-based college majors. Based on results obtained from a pilot sample of 115 college students, 52 math-related tasks were selected from an initial 75-item pool. Item content included everyday math tasks, math problems, and math-based college courses. Subjects, 153 female and 109 male undergraduates, were asked to indicate thei. degree of confidence in their ability to successfully perform the tasks or problems or to complete the college course with a grade of "B" or better. Results indicated that the mathematics self-efficacy scale was an internally consistent measure having moderate relationships to related variables, e.g., mathematics anxiety. As predicted, the math-related self-efficacy expectations of college males were significantly stronger than were those of college females, particularly with regard to math-related college courses. Mathematics self-efficacy expectations, but not any mathematics performance index, contributed significantly to the prediction of the degree to which students selected science-based college majors, thus supporting the postulated role of cognitive mediational factors in educational and career choice behavior. The utility of the concept and measure of mathematics self-efficacy expectations for the understanding and treatment of math anxiety and math-avoidant behaviors is discussed.

Mathematics Self-Efficacy Expectations, Math Performance, and the Consideration of Math-Related Majors

One factor gaining increased credence as an explanation for women's continued underrepresentation in most scientific and technical fields is their lack of preparation, relative to that of men, in mathematics. The importance of mathematics background to subsequent educational and career options and decisions has been demonstrated by researchers such as Sells (1980), who concluded that mathematics was the "critical filter" in the pursuit of scientific and technical careers, and Goldman and Hewitt (1976), who found that SAT Mathematics scores were an important determiner of choice of a science versus non-science college major.

While the debate concerning the causes of the persistent gender differences in mathematics achievement continues (e.g., Benbow & Stanley, 1980; Fennema & Sherman, 1977; Hyde, 1981; Maccoby & Jacklin, 1974), the existence of gender differences in mathematics background is well-established. Females take significantly fewer math courses than do males in both high school and college, and far fewer women than men elect to major in mathematics (Ernest, 1976; Hewitt & Goldman, 1975). Given the strong relationship of mathematics background to math achievement (Ernest, 1976; Green, 1974) and to subsequent educational and career options, the problem of math avoidance, especially among females, has been of increasing concern to counselors engaged in educational and career counseling and programming.

Math avoidance has been most frequently explained as the result of negative attitudes and affective reactions in relationship to mathematics (Fennema & Sherman, 1977, 1978; Hendel, 1980; Sherman & Fennema, 1977). In particular, the counseling literature has focused on the concept of math anxiety, defined, for example, by Richardson & Suinn (1972) 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" (p. 551). Recent research has addressed the measurement, correlates, and treatment of math anxiety (Betz, 1978; Hendel, 1980; Hendel & Davis, 1978; Richardson & Suinn, 1972; Rounds & Hendel, 1980).

While the concept of math anxiety has had clear heuristic and applied utility, a related concept having broader and possibly more direct implications for both the understanding and treatment of math avoidance is that of mathematics self-efficacy expectations, deriving from Bandura's (1977) theory of self-efficacy expectations and the extension of that theory to career-related behaviors (Hackett & Betz, 1981). Bandura (1977) postulates that self-efficacy expectations, i.e., a person's beliefs concerning his/her ability to successfully perform a given task or behavior, are the major mediators of behavior and behavior change. In particular, Bandura suggests that counseling interventions designed to change behavior are effective because and to the extent that they increase the client's expectations of self-efficacy with respect to the problematic, e.g., previously avoided, behavior. Thus, interventions designed to facilitate approach versus avoidance behavior should, according to Bandura, be focused on increasing self-efficacy expectations with respect to that domain of behavior.

In addition to postulating the mechanism by which behavior change is best effected, Bandura specifies four sources of information through which self-efficacy expectations are learned and by which they can be modified. These sources of information are: 1) performance accomplishments, i.e., experiences of successfully performing the behaviors in question; 2) vicarious learning or modeling; 3) verbal persuasion, e.g., encouragement and support from others; and 4) emotional arousal, e.g., anxiety, in connection with the behavior. The last source of information is viewed by Bandura as a "co-effect" of self-efficacy expectations. In other words, the level of anxiety is seen to covary inversely with the level and strength of self-efficacy expectations; as self-efficacy expectations increase, anxiety should decrease and vice versa. Thus, interventions focused on increasing self-efficacy expectations via attention to the sources of efficacy information should increase approach versus avoidant behavior and, concurrently, decrease anxiety in relationship to the behavior.

In a recent extension of Bandura's (1977) theory, Hackett and Betz (1981) propose the utility of the concept of self-efficacy expectations to career-related behaviors. More specifically, they postulate that low or weak self-efficacy expectations with regard to behavioral domains important in career pursuits, e.g., mathematics, may restrict career options and/or otherwise influence career decisions, and that interventions designed to increase career-related self-efficacy expectations could be an important and useful focus of career counseling. In particular, application of the concept of self-efficacy expectations to the domain of mathematics could have considerable utility for the understanding and treatment of math avoidance and anxiety.

Thus, the overall purpose of the present study was to investigate the applicability of Bandura's (1977) self-efficacy theory and the Hackett and Betz (1981) extension of that theory to the domain of mathematics behavior. More specifically, its purposes were: 1) to develop a measure of mathematics self-efficacy expectations; 2) to evaluate the psychometric and normative properties of the instrument and its relationship to mathematics performance and other attitudinal and personality variables; 3) to test the hypothesis, derived from the Hackett and Betz (1981) model and from previous literature, that the mathematics self-efficacy expectations of college males are stronger than those of college females; 4) to examine the hypothesis, again derived from Hackett and Betz, (1981), that mathematics self-efficacy expectations are importantly related to career decision-making and, in particular, to the extent to which college students select mathematics-related or science-based majors; and 5) to test the hypothesis, derived from self-efficacy theory (Bandura, 1977; Hackett & Betz, 1981) that mathematics self-efficacy expectations are a better predictor than prior mathematics performance of math-related behaviors such as math-related career choices.

Method

Instruments

Mathematics Self-Efficacy Scale. The first step in the development of the measure of self-efficacy expectations with regard to mathematics involved specification of the domain of mathematics-related behaviors. After review of existing measures of either mathematics anxiety or math confidence, three domains were identified as relevant to the study of math-related self-efficacy expectations. The first type of behavior identified as relevant was the solving of math problems, i.e., problems similar to those found on standardized tests of mathematical aptitude and achievement. This approach to the assessment of attitudes toward math was utilized in Dowling's (Note 1) Mathematics Confidence Scale. The second domain, similar to that represented by the Math Anxiety Rating Scale (MARS: Richardson & Suinn, 1972) was defined as including mathematics behaviors used in everyday life, e.g., balancing a checkbook. Finally, a domain representing capability of satisfactory performance in college courses requiring various degrees of mathematics knowledge and mastery was specified. This aspect of behavior has not previously been used in the study of attitudes toward math but was considered particularly appropriate for examination in samples of college students. Thus, self-efficacy expectations with regard to mathematics were operationally defined to include perceptions of performance capability in relationship to math problems, everyday math tasks, and mathematics-related college coursework.

Following specification of the behaviors to be assessed, items reflective of each behavioral domain were generated. Items for the Math Problems scale of the self-efficacy measure were adapted from Dowling's (Note 1) Mathematics Confidence Scale. The latter scale contains 18 math problems distributed equally among three content areas, i.e., Arithmetic, Algebra, and Geometry, three types of operations, and two levels of abstraction. Because the Mathematics Confidence Scale is well-balanced in terms of item content and, in addition, allows assessment of actual performance as well as of self-efficacy expectations, all 18 items were selected for inclusion in the measure of mathematics self-efficacy.

Items for the domain of everyday math tasks were generated in two ways, i.e., through the adaptation of items contained in the Math Anxiety Rating Scale and by requesting students to submit examples of math usage in daily life. Using these two sources of items, 30 behaviors reflective of the utilization of math in every tasks and activities were selected for inclusion in the initial instrument.

College courses relevant to the assessment of math self-efficacy were defined as: 1) mathematics courses per se; and 2) courses perceived by college students as requiring mathematics background and knowledge. In order to determine courses meeting the latter criterion, students were asked to indicate the amount of math coursework they felt was necessary to complete each of 32 college majors. Responses ranged from "None" (0) to "Extensive" (5). In addition, college courses paralleling the college majors samples above were included in the initial measure of mathematics self-efficacy expectations.

In summary, the initial measure of mathematics self-efficacy expectations consisted of 75 items, 18 representing math problems, 30 representing math tasks, and 27 representing college courses.[1] For the math tasks and math problems subscales subjects were asked to indicate their confidence in their ability to successfully perform the task or solve the problem. For the college course subscale, subjects were asked to indicate their confidence in their ability to complete the course with a grade of "B" or better. Confidence ratings were obtained on a 10-point scale ranging from

"No confidence at all" (0) to "Complete confidence" (9). Total scores were calculated separately for each of the three subscales and for the total of 75 items.

Refinement of the original 75-item scale was accomplished by its administration to a sample of 115 undergraduate students. Subjects were asked to indicate their degree of confidence in their ability to perform each task and were also asked to indicate the degree of difficulty of the task for the average student; difficulty ratings were obtained on a scale ranging from "Not at all difficult" (0) to "Extremely difficult" (9). Subjects were also administered the questionnaire assessing perceived math requirements of various college majors. Based on the results of analyses of item difficulty and item discrimination (item-total score correlations), the math tasks subscale was reduced from 30 to 18 items. Item difficulty and discrimination data and perceptions of the extent of math background and knowledge required were used to select the 16 college courses retained in the refined instrument. The math problems subscale, because it was derived from an existing instrument, was retained in its entirety.

Thus, the final version of the Mathematics Self-Efficacy Scale consisted of 18 math tasks, 16 math-related college courses, and 18 math problems, or a total of 52 items. The items of the tasks, college courses, and problems subscales are shown in Tables 1, 2, and 3, respectively. As in the original instruments, the response format for the revised measure of math self-efficacy involved asking subjects to indicate their confidence in their ability to successfully perform the task, solve the problem, or obtain a grade of "B" or better in the college course. Responses were obtained on a 10-point scale ranging from "No confidence at all" (0) to "Complete confidence" (10). Total scores were calculated for the math tasks, math courses, and math problems subscales separately and for the 52-item total scale.

Mathematics Performance. In order to assess mathematics ability, the performance subscale of the Dowling (Note 1) Mathematics Confidence Scale was employed. This scale consists of 18 items corresponding to the 18-item Math Problem subscale used to assess self-efficacy with regard to mathematics problems. Dowling created the performance scale so that assessments of confidence in mathematics problem-solving could be directly compared to actual performance on the same types of problems.

The mathematics performance scale can be divided into three, non-orthogonal subscales characterizing the types of problems to be solved, the types of operations 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 requiring computation, comprehension, or application in order to solve the problems; and the Context scale contains two subscales of 9 items each consisting of real or abstract problems. Scores for all scales and subscales were determined by adding the number correct and obtaining a mean score for each scale; thus, scores for all scales ranged from "0" to "1".

American College Test (ACT) Mathematics Usage scores were obtained from university records as an additional index of mathematics performance.

Attitudes toward mathematics. In order to examine the relationships of mathematics self-efficacy expectations to the related construct of math anxiety and to other attitudes toward mathematics, a revised version of the Fennema-Sherman Mathematics Attitudes Scales (Fennema & Sherman, 1976) was utilized. The Fennema-Sherman scales, revised for use with college students (Betz, 1978), include five 10-item scales, i.e., math anxiety, confidence in learning mathematics, perceptions of the usefulness of math, perceptions of math 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 math, e.g., less math anxiety, less tendency to view math as a primarily male domain, and greater tendency to view math as useful.

Sex role orientation. In order to examine the relationship of sex role variables as well as gender itself to mathematics self-efficacy expectations, the Bem Sex Role Inventory (BSRI; Bem, 1974) was utilized. The BSRI contains a Masculinity scale and a Femininity scale, each of which contains 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 subject 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.

Subjects

All subjects were undergraduate students enrolled in introductory psychology courses. Participation in the study was voluntary and subjects received course credit for their participation. The first sample of subjects, 51 male and 64 female, constituted the pilot sample for use in the refinement of the preliminary pool of items generated to assess mathematics self-efficacy. The second sample, consisting of 153 female and 109 male students, was used to permit the investigation of the relationships of scores on the revised Mathematics Self-Efficacy Scale (MSES) to other attitudinal, personality, and career choice variables.

Procedures

Data collection proceeded in two phases completed during the autumn term of 1980. In the pilot study, subjects were administered the original (75-item) version of the MSES, the measure assessing perceived difficulty of the math tasks, problems, and college courses, the math performance scale, and the questionnaire assessing the perceived mathematics requirements of various college majors. These data were used in revising the Mathematics Self-Efficacy Scale for use in the subsequent study.

The second study involved the administration of the revised (52-item) MSES, the math performance scale, the Fennema-Sherman scales, the BSRI, and a questionnaire requesting information concerning mathematics background and college major and occupational preferences.

Analysis of Data

Item difficulty and discrimination data were obtained for each of the 52 items constituting the Mathematics Self-Efficacy Scale. In accordance with Bandura's (1977) use of the concept of heirarchies of task difficulty in the examination of self-efficacy expectations, item difficulty was herein defined as the mean level of confidence associated with each math-related behavioral item. Sex differences in mathematics self-efficacy expectations were examined separately for each of the 52 items, for the math tasks, problems, and courses subscale scores, and for the total score on the 52-item scale.

Relationships of mathematics self-efficacy expectations to math performance, math anxiety, attitudes toward math, and masculinity and femininity scores were examined using Pearson product-moment correlations. Finally, subjects' college major preferences 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. Scores of 1, for example, are associated with majors such as art or theatre, while scores of 5 describe majors in the physical sciences, engineering, and mathematics. The science-nonscience continuum scores were used as the dependent variable in a stepwise multiple regression analysis; independent variables utilized were sex, the MSES total score, math performance scale scores, years of high school math, the Fennema-Sherman math anxiety and mathematics confidence scores, ACT math scores, and the BSRI Masculinity score.

Results

Prior to other analyses, analyses of the scale properties of the revised version of the Mathematics Self-Efficacy Scale were performed. Results indicated that item-total score correlations ranged from .29 to .63 for the math tasks, .33 to .73 for the math courses, and from .24 to .66 for the math problems. The resulting internal consistency reliabilities (coefficient alpha) of the three subscales were .90, .93, and .92. The reliability of the total 52-item scale was .96.

Table 1 presents the mean scores of male and female college students on the 18 item constituting the Math Tasks scale of the measure of mathematics self-efficacy expectations; items are presented in a heirarchy of difficulty ranging from most to least difficult.. As shown in the table, the items "Work with a slide rule" (M=4.0) and "Determine how much interest you will end up paying on a loan. . ." (M=5.7) were perceived as most difficult, while the items "Figure out how much you would save if there is a 15% markdown on an item you wish to buy" (M=7.4) and "Calculate recipe quantities for a dinner for three when the original recipe is for 12 people" (M=7.6) were perceived as least difficult. Males reported significantly stronger self-efficacy expectations with respect to 8 of the 18 items. Of the remaining 10 items, males reported greater confidence on seven of the ten. Interestingly, the three items on which females reported slightly (although not statistically significantly) stronger self-efficacy expectations involved traditionally-female activities, i.e., making curtains (Item 5), grocery shopping (item 9), and calculating recipe quantities (Item 18).

Insert Table 1 about here

Table 2 provides means and standard deviations of self-efficacy expectations with respect to the 16 college courses; again, items are arranged from most to least difficult. As shown in the table, the most difficult courses were Advanced Calculus (M=3.1), Calculus (M=3.8), and

Biochemistry (M=3.9), while those perceived as least difficult were Basic College Math (M=7.3) and Algebra I (M=7.1). Males reported significantly stronger self-efficacy expectations with respect to 11 of the courses, and the means of males were higher than those of females on the remaining 5 courses.

Insert Table 2 about here

Means and standard deviations for the items of the Math Problems subscale of the self-efficacy measure are shown in Table 3. Males reported significantly stronger self-efficacy expectations with respect to 5 of the 18 math problems, and on all 18 problems males' self-efficacy expectations were equal to or greater than those of females. Thus, males reported significantly stronger self-efficacy expectations than did females on 24 of the 52 items assessing mathematics self-efficacy; sex differences were most consistent on the courses subscale and least so in relationship to math problems.

Insert Table 3 about here

Table 4 provides data concerning the total scores of female and male college students on the indices of math self-efficacy, math anxiety and math attitudes. Consistent with the stronger self-efficacy expectations of males with regard to the individual items, males obtained significantly higher scores on all three subscales of the MSES and on the total scale.

The scores of males also indicated lower levels of math anxiety (higher scores on this scale indicate more positive attitudes toward math), greater confidence in their math ability, and a greater tendency to view math as useful than did the scores of females. In contrast, females obtained significantly higher scores on the Math as a Male Domain scale, indicating less tendency to view math as a more appropriate field of study for males than females than did males.

Insert Table 4 about here

The means and standard deviations of females and males on the three scales of the mathematics performance test and on the ACT Mathematics score are presented in Table 5. Significant sex differences in favor of men are present on all but the Comprehension subscale of the Demand scale and the Abstract subscale of the Context scale; significant sex differences exist on the Math ACT Score as well.

Insert Table 5 about here

Table 6 shows the relationships of mathematics self-efficacy expectations to mathematics attitudes, mathematics performance, and to the BSRI Masculinity and Femininity Scales. Relationships of math self-efficacy expectations to math attitudes are, in general, statistically significant and of moderate magnitude. Students with stronger mathematics self-efficacy report lc er levels of math anxiety, higher levels of overall confidence and effectance motivation, and a greater tendency to view math as useful.

Mathematics self-efficacy expectations are also significantly related to the two indices of mathematics performance, the total score on the math performance scale and the ACT Mathematics Score, with the latter relationship yielding higher intercorrelations. In addition, stronger math self-efficacy expectations are related to higher scores on the BSRI Masculinity scale but are unrelated to the BSRI Femininity Scores.

Insert Table 6 about here

Finally, Table 7 shows the results of the stepwise multiple regression analysis using the Goldman and Hewitt (1976) science code of declared college major as the dependent variable. Of the independent variables utilized, i.e., sex, mathematics self-efficacy expectations, years of high school math, math anxiety, the Fennema-Sherman Math Confidence scale scores, mathematics performance, ACT Math scores, and BSRI Masculinity scores, the former four contributed significantly to the prediction of science code of college major choice. Subjects reporting stronger mathematics self-efficacy expectations, more years of high school math, and lower levels of math anxiety were more likely to have selected science-based college majors, as were male students in contrast with female students. The performance variables did not enter significantly into the equation. The obtained multiple regression coefficient was R=.62, and the four predictors accounted for 36% of the variance in the science code of major choice.

Insert Table 7 about here

Discussion

The present research resulted in the development of an internally consistent measure of mathematics self-efficacy expectations. For each subscale, a heirarchy of item difficulties based on subjects' degree of confidence in their ability to complete each task was obtained. Data regarding sex differences in mathematics self-efficacy were in accordance with theoretical prediction; males reported significantly stronger self-efficacy expectations than did females on 24 of the 52 items, and the means of males were higher than those of females on the majority of the remaining items. Only on three everyday math tasks involving stereotypically feminine activities, e.g., cooking, sewing, were the means of females higher than those of males. Overall, the data suggest that, relative to males, the math-related cognitions of females are weakest relative to math-related college coursework and strongest in relationship to everyday math tasks involving traditionally-female activities.

Data presented on sex differences in mathematics performance and the relationship between math achievement and mathematics self-efficacy expectations indicated moderate correlations between the two. This finding is also in keeping with theoretical predictions that self-efficacy expectations are informed by performance accomplishments, but not totally congruent with ability. Therefore, although women's mathematics performance may be somewhat lower than men's, this finding does not fully explain the sex differences in mathematics self-efficacy expectations or the sex differences in math-related career choice.

Data regarding the relationship of math self-efficacy to other variables provided intitial evidence for the construct validity of the instrument; a moderate positive relationship with a global measure of math confidence and a moderate negative relationship with math anxiety were observed. Thus, Bandura's (1977) postulate that anxiety is an inverse "coeffect" of self-efficacy expectations was supported by the present findings. Mathematics self-efficacy expectations were also positively related to degree of self-reported masculinity but were unrelated to femininity, thus supporting recent findings that higher levels of masculinity or instrumentality appear to facilitate confidence and/or self-esteem (Spence & Helmreich, 1980). Thus, a relationship observed for global measures of self-esteem appears also to characterize the relationship of masculinity to a domain- and task-specific measure of beliefs in one's performance capabilities.

Mathematics self-efficacy expectations were also found to be significant predictors of the degree to which college major choices are science-based. While Goldman and Hewitt (1976) found that mathematics aptitude test scores were important predictors of choice of science majors, the present study suggests the importance of beliefs about those capabilities in influencing choices of science versus non-science majors and careers. The stepwise multiple regression analysis performed herein included math performance and Math ACT scores as independent variables, but these scores did not contribute significantly to the prediction of science code when the variance attributable to math self-efficacy, sex, years of high school math, and math anxiety had been removed in previous steps of the regression analysis. While the nature of the causal relationships of math background, math ability, and math self-efficacy expectations, including the coeffect of math anxiety, to each other and to the selection of college coursework and majors needs further empirical investigation, the present study strongly suggests the role of cognitions of self-efficacy in influencing educational and career decisions.

The measure developed herein, while in need of further evaluative research, has considerable potential utility for the assessment and treatment of problems of math avoidance and math anxiety. First, its use as an assessment device yields both a general index of the strength of mathematics self-efficacy expectations and information concerning the individual's degree of confidence with respect to each of 52 math-related tasks or behaviors. Because of the behavioral specificity of the information yielded, treatment programs can be designed to incorporate a focus on increasing self-efficacy expectations with respect to those specific behaviors; this, in turn, should generalize to other math-related behaviors. Further, the availability of a heirarchy of task difficulty as presented herein or as determined individually for a given client allows interventions, e.g., facilitating successful performance accomplishments, to begin with relatively easy tasks and to proceed with successively more difficult tasks as self-efficacy expectations are increased and strengthened. Thus, the concept of self-efficacy expectations and an instrument such as that developed herein provide both a structure for interventions and specific behaviors with which to begin and from which to progress with those interventions. While related concepts such as mathematics confidence and math anxiety have been useful both conceptually and heuristically, the behaviorally specific nature of the concept of self-efficacy expectations offers advantages in terms of assessment, treatment, and the relationship between assessment and treatment.

The finding that females' self-efficacy expectations were equivalent to those of males when the tasks involved stereotypically feminine activities has both theoretical and practical importance. Bandura postulates that self-efficacy expectations are learned via, among other things, successful performance accomplishments and vicarious learning. Since the early experiences of females are likely to emphasize domestic activities such as cooking and sewing, their higher self-efficacy expectations with respect to the math needed in these activities is in accord with Bandura's predictions. More importantly, though, these findings suggest that the inclusion of traditionally-female content areas in math problems and in the treatment of math avoidance and anxiety may facilitate the development of confidence and the frequency of "approach" behavior. It is likely that many young women are not aware that they are successfully using math in ordinary activities and, thus, fail to acknowledge the "successful performance accomplishments" that would increase their expectations of math-related self-efficacy.

In summary, the concept and measures of mathematics self-efficacy expectations are proposed to have utility for the understanding and treatment of math-avoidant behaviors. Given the observed relationship of math self-efficacy to the major choices of college students and the general importance of mathematics to a range of career options, further study of the effectiveness of interventions designed to increase expectations of math-related self-efficacy expectations appears warranted.

Footnotes

Requests for reprints should be sent to Gail Hackett, Faculty of Special Services, The Ohio State University, 257 Arps Hall, 1945 N. High Street, Columbus, Ohio, 43210.

[1]An extended description of the procedures utilized in the construction and refinement of the Mathematics Self-Efficacy Scale is available from the authors.

Reference Notes

1. Dowling, D.M. The development of a mathematics confidence scale and its application in the study of confidence in women college students. Unpublished doctoral dissertation, Department of Mathematics Education, Ohio State University, 1978.

REFERENCES

Bandura, A. Self-efficacy: Toward a unifying theory of behavioral change. Psychological Review, 1977, 84, 191-215.

Bem, S.L. The measurement of psychological androgyny. Journal of Consulting and Clinical Psychology, 1974, 42, 155-162.

Bem, S.L. On the utility of alternate procedures for assessing psychological androgyny. Journal of Consulting and Clinical Psychology, 1977, 45, 196-205.

Betz, N.E. Prevalence, distribution, and correlates of math anxiety in college students. Journal of Counseling Psychology, 1978, 25, 441-448.

Ernest, J. Mathematics and sex. The American Mathematical Monthly, 1976, 83, 595-614.

Fennema, E. and Sherman, J.A. Fennema-Sherman Mathematics Attitude Scales: Instruments designed to measure attitudes toward the learning of mathematics by females and males. JSAS Catalog of Selected Documents in Psychology, 1976, 6, 31. (Ms. No. 1225).

Fennema, E. and Sherman, J.A. Sex-related differences in mathematics achievement, spatial visualization, and affective factors. American Educational Research Journal, 1977, 14, 51-71.

Fennema, E. and Sherman, J.A. Sex-related differences in mathematics achievement and related factors: A further study. Journal for Research in Mathematics Education, 1978, 9. 189-203.

Goldman, R.D. and Hewitt, B.N. The scholastic aptitude test 'explains' why college men major in science more often than college women. Journal of Counseling Psychology, 1976, 23, 50-54.

Green, D.R. The aptitude-achievement distinction. New York: McGraw Hill, 1974.

Hackett, G. and Betz, N.E. A self-efficacy approach to the career development of women. Journal of Vocational Behavior, 1981, 18, 326-339.

Hendel, D.D Experiential and affective correlates of math anxiety in adult women. Psychology of Women Quarterly, 1980, 5, 219-230.

Hendel, D.D. and Daivs, S.O. Effectiveness of an intervention strategy for reducing mathematics anxiety. Journal of Counseling Psychology, 1978, 25, 429-434.

Hewitt, B.N. and Goldman, R.D. Occam's razor slices through the myth that college women overachieve. Journal of Educational Psychology, 1975, 67, 325-330.

Hyde, J.S. How large are cognitive gender differences? A meta-analysis using ω^2 and d. American Psychologist, 1981, 36, 892-901.

Maccoby, E.E. and Jacklin, C.N. The psychology of sex differences. Stanford, California: Stanford University Press, 1974.

Richardson, R. and Suinn, R.N. The mathematics anxiety rating scale: Psychometric data. Journal of Counseling Psychology, 1972, 19, 551-554.

Rounds, J.B. and Hendel, D.D. Measurement and dimensionality of mathematics anxiety. Journal of Counseling Psychology, 1980, 27, 138-149.

Sells, L.W. The mathematics filter and the education of women and minorities. In L.H. Fox, L. Brody, and D. Tobin (Eds). Women and the mathematical mystique. Baltimore: Johns Hopkins, 1980.

Sherman, J. Predicting mathematics performance in high school girls and boys. Journal of Educational Psychology, 1979, 71, 242-249.

Sherman, J. and Fennema, E. The study of mathematics by high school girls and boys: Related variables. American Educational Research Journal, 1977, 14, 159-168.

Spence, J.T. and Helmreich, R.L. Masculine instrumentality and feminine expressiveness: Their relationships with sex role attitudes and behaviors. Psychology of Women Quarterly, 1980, 5, 147-163.

Spence, J.T., Helmreich, R., and Stapp, J. The Personal Attributes Questionnaire: A measure of sex role stereotypes and masculinity - femininity. JSAS Catalog of Selected Documents in Psychology, 1974, 4, 127. (Ms. No. 617)

Table 1

Sex Differences in Mathematics Self-Efficacy: Math Tasks

Items[a]	Total (N=264) M	Total (N=264) SD	Females (N=153) M	Females (N=153) SD	Males (N=109) M	Males (N=109) SD	Test of Significance t
1. Work with a slide rule	4.0	2.8	3.8	2.7	4.3	2.9	-1.4
2. Determine how much interest you will end up paying on a $675 loan over 2 years at 14 3/4 interest	5.7	2.4	5.3	2.3	6.1	2.4	-2.6**
3. Figure out how much lumber you need to buy in order to build a set of bookshelves	5.9	2.3	5.3	2.3	6.8	2.1	-5.4***
4. Compute your income taxes for the year	5.9	2.2	5.8	2.2	6.1	2.2	-1.4
5. Figure out how much material to buy in order to make curtains	6.1	2.2	6.1	2.2	6.0	2.2	.4
6. Understand a graph accompanying an article on business profits	6.2	2.0	6.0	1.9	6.5	2.1	-1.9
7. Understand how much interest you will earn on your savings account in 6 months, and how that interest is computed	6.3	2.2	6.1	2.2	6.6	2.1	-1.9
8. Add two large numbers (e.g., 5739 + 62543) in your head	6.5	2.2	6.2	2.0	6.9	2.0	-2.9**
9. Estimate your grocery bill in your head as you pick up items	6.6	1.8	6.6	1.8	6.6	1.8	.4
10. Determine the amount of sales tax on a clothing purchase	6.8	1.9	6.6	1.9	7.0	2.0	-1.7

Table 1 (continued)

Items	Total (N=264)		Females (N=153)		Males (N=109)		Test of Significance
	M	SD	M	SD	M	SD	t
11. Figure out the tip on your part of a dinner bill split 8 ways	7.1	1.8	6.9	1.9	7.5	1.6	-2.5**
12. Figure out how long it will take to travel from City A to City B driving at 55 mph	7.2	1.8	6.8	1.9	7.8	1.6	-4.5***
13. Compute your car's gas mileage	7.2	1.9	6.7	2.0	8.1	1.4	-6.5***
14. Set up a monthly budget for yourself	7.3	1.5	7.2	1.5	7.5	1.6	-1.3
15. Balance your checkbook without a mistake	7.4	2.0	7.1	2.1	7.8	1.7	-2.9**
16. Figure out which of two summer jobs is the better offer: one with a higher salary but no benefits, the other with a lower salary plus room, board, and travel expenses	7.4	1.5	7.3	1.5	7.5	1.6	-1.0
17. Figure out how much you would save if there is a 15% markdown on an item you wish to buy	7.4	1.7	7.2	1.8	7.6	1.5	-2.2*
18. Calculate recipe quantities for a dinner for when the original recipe is for 12 people	7.6	1.7	7.6	1.5	7.5	1.9	.6

Note. Items adapted from the Mathematics Anxiety Rating Scale (MARS, Richardson & Suinn, 1972).
[a] Items are arranged in a heirarchy of overall difficulty from most difficult to least difficult. Item numbers reflect order of difficulty rather than the placement of items in the instrument administered.

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

Table 2

Sex Differences in Mathematics
Self-Efficacy: College Courses

Courses[a]	Total (N=264) M	Total (N=264) SD	Females (N=153) M	Females (N=153) SD	Males (N=109) M	Males (N=109) SD	Test of Significance t
Advanced Calculus	3.1	2.5	2.6	2.3	3.8	2.6	-4.1***
Calculus	3.8	2.5	3.3	2.4	4.4	2.5	-3.4***
Biochemistry	3.9	1.9	3.8	1.8	4.1	1.9	-1.3
Statistics	4.5	1.9	4.2	1.8	4.9	1.9	-2.8**
Computer Science	4.6	2.0	4.1	1.8	5.2	2.1	-4.3***
Physiology	4.8	1.8	4.6	1.8	5.2	1.8	-2.6**
Trigonometry	4.9	2.7	4.4	2.7	5.5	2.7	-3.4***
Economics	4.9	1.8	4.6	1.8	5.3	1.8	-2.8**
Zoology	5.0	1.9	4.8	1.9	5.3	1.9	-2.1*
Accounting	5.2	2.1	4.9	2.1	5.5	2.0	-2.2*
Philosophy	5.3	2.0	5.2	2.1	5.5	1.9	-1.1
Business Administration	5.6	1.8	5.5	1.8	5.7	1.8	-1.2
Geometry	5.8	2.4	5.3	2.3	6.4	2.3	-3.8***
Algebra II	6.3	2.5	5.9	2.6	6.8	2.3	-2.9**
Algebra I	7.1	2.3	6.9	2.2	7.2	2.4	-1.1
Basic College Math	7.3	2.1	7.1	2.1	7.5	1.9	-1.8

[a]Courses are arranged in a heirarchy of overall perceived difficulty from most difficult to least difficult.

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

Table 3

Sex Differences in Mathematics Self-Efficacy Expectations: Math Problems[a]

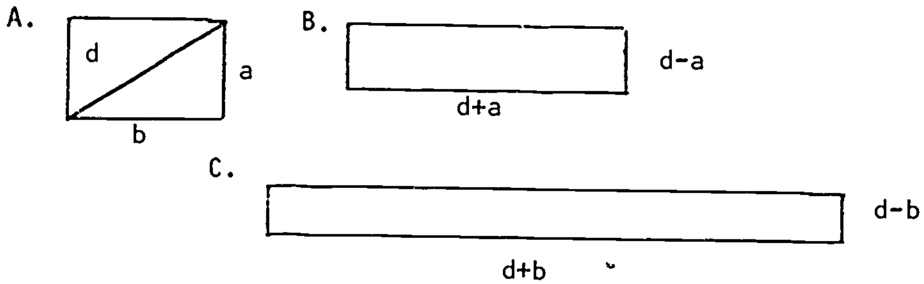
Problems[b]	Total (N=264) M	Total (N=264) SD	Females (N=153) M	Females (N=153) SD	Males (N=109) M	Males (N=109) SD	Test of Significance t
1. In Starville, an operation ° on any numbers a and b is defined by a ° b = a x (a + b). Then 2°3 equals __?__	5.7	2.9	5.3	2.9	6.1	2.8	-2.3*
2. Sally needs three pieces of poster board for a class project. If the boards are represented by rectangles A, B, C, arrange their areas in increasing order. (assume b > a) 	6.0	2.1	5.8	2.1	6.4	2.1	-2.3**
3. The average of three numbers is 30. The fourth number is at least 10. What is the smallest average of the four numbers?	6.5	1.9	6.1	1.8	7.0	1.9	-3.8***
4. To construct a table, Michele needs 4 pieces of wood 2.5 feet long for the legs. She wants to determine how much wood she will need for five tables. She reasons: 5 x (4 x 2.5) = (5 x 4) x 2.5 Which number principle is she using?	6.6	2.2	6.6	2.3	6.6	2.2	- .1
5. The opposite angles of a parallelogram are ______.	6.8	2.5	6.6	2.5	7.1	2.5	-1.5

Table 3 (continued)

Problems[b]	Total (N=264) M	Total (N=264) SD	Females (N=153) M	Females (N=153) SD	Males (N=109) M	Males (N=109) SD	Test of Significance t
6. Five points are on a line. T is next to G. K is next to H. C is next to T. H is next to G. Determine the relative positions of the points along the line.	7.0	2.1	7.0	2.1	7.1	2.2	- .1
7. There are three numbers. The second is twice the first, and the first is one-third of the other number. Their sum is 48. Find the largest number.	7.1	1.9	7.1	1.8	7.1	1.9	.04
8. In a certain triangle, the shortest side is 6 inches, the longest side is twice as long as the shortest side and the third side is 3.4 inches shorter than the longest side. What is the sum of the three sides in inches?	7.1	1.9	7.0	1.9	7.3	1.9	-1.3
9. The hands of a clock form an obtuse angle at ________ o'clock.	7.2	2.2	7.0	2.3	7.4	2.1	-1.6
10. Bridget buys a packet containing 9-cent and 13-cent stamps for $2.65. If there are 25 stamps in the packet, how many are 13-cent stamps?	7.3	1.9	7.3	1.8	7.3	2.0	.2
11. A living room set consisting of one sofa and one chair is priced at $200. If the price of the sofa is 50% more than the price of the chair, find the price of the sofa.	7.3	1.7	7.1	1.7	7.7	1.6	-3.1**

Table 3 (continued)

Problems[b]	Total (N=264) M	Total (N=264) SD	Females (N=153) M	Females (N=153) SD	Males (N=109) M	Males (N=109) SD	Test of Significance t
12. Write an equation which expressed the condition that "the product of two numbers R and S is one less than twice their sum."	7.4	1.9	7.2	1.9	7.5	1.9	-1.2
13. Set up the problem to be done to find the number asked for in the expression "six less than twice 4 5/6?"	7.4	2.0	7.3	1.9	7.5	2.2	- .7
14. On a certain map, 7/8 inch represents 200 miles. How far apart are two towns whose distance apart on the map is 3½ inches?	7.7	1.8	7.6	1.9	8.0	1.6	-1.7
15. The formula for converting temperature from degrees Centigrade to degrees Fahrenheit is F = 9/5 C +32. A temperature of 20 degrees Centigrade is how many degrees Fahrenheit?	7.8	1.9	7.7	2.0	8.0	1.8	-1.2
16. 3 3/4 - 1/2 =	8.2	1.4	8.0	1.4	8.5	1.2	-3.0**
17. If 3x - 2 = 16 - 6x, what does x equal?	8.3	1.4	8.3	1.4	8.4	1.4	- .6
18. Fred's bill for some household supplies was $13.64. If he paid for the items with a $20, how much change should he receive?	8.7	.9	8.6	1.2	8.8	.5	-1.7

Note. Item responses were obtained on a 10-point scale ranging from "Not at all confident" (0) to "Completely Confident" (9)

[a] Problems taken from Dowling's (Note 1) Mathematics Confidence Scale.

[b] Problems are arranged in a heirarchy of overall perceived difficulty from most difficult to least difficult.

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

Table 4

Sex Differences in Mathematics Self-Efficacy
Total Scores and in Attitudes Toward Mathematics

Scale	Females (N=153) M	Females (N=153) SD	Males (N=109) M	Males (N=109) SD	t
Mathematics Self-Efficacy Expectations[a]					
Math Tasks	6.4	1.2	7.0	1.2	-3.9***
College Courses	4.9	1.4	5.5	1.5	-3.5***
Math Problems	7.1	1.3	7.5	1.3	-2.3*
Total Score[b]	6.2	1.0	6.7	1.2	-3.4***
Mathematics Attitudes[c]					
Math Anxiety	29.5	8.9	31.9	8.4	-2.2*
Math Confidence	31.8	9.9	35.3	9.2	-2.8**
Math as a Male Domain	36.7	5.7	34.8	6.2	2.5*
Usefulness of Math	36.2	7.5	38.5	7.3	-2.4*
Effectance Motivation	31.2	7.9	32.5	8.1	-1.3

[a] Higher scores on the mathematics self-efficacy scale indicate greater confidence in ability to accomplish the math-related tasks.

[b] Means based on 147 females and 108 males.

[c] Higher scores indicate more positive attitudes toward mathematics, e.g., less anxiety toward math, less tendency to view math as a male domain.

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

Table 5

Sex Differences on the Mathematics
Performance Scale and Math ACT Scores

Scale	Females (N=153) M	Females (N=153) SD	Males (N=109) M	Males (N=109) SD	t
Mathematics Performance[a]					
Components Subscales					
Arithmetic	.54	.25	.60	.24	-2.0*
Algebra	.59	.28	.68	.24	-2.7**
Geometry	.62	.25	.69	.26	-2.0*
Demand Subscales					
Computation	.67	.27	.76	.23	-2.8**
Comprehension	.63	.25	.69	.24	-1.9
Application	.50	.25	.57	.26	-2.1*
Context Subscales					
Real	.61	.24	.70	.22	-3.3***
Abstract	.59	.23	.64	.24	-1.7
ACT Mathematics Score[b]	18.8	6.8	21.0	5.8	-2.3*

a Scores range from 0.0 to 1.0; higher scores indicate better performance on the eighteen-item test.

b Means based on 111 females and 70 males.

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

Table 6

Relationships of Mathematics Self-Efficacy Expectations to Mathematics Attitudes, Math Performance, and Sex Role Variables

Variable	Mathematics Self-Efficacy Score Math Tasks r	Courses r	Problems r	Total Score r
Attitudes Toward Math				
Math Anxiety	.40	.61	.43	.56
Math Confidence	.46	.73	.53	.66
Math as a Male Domain	.03	.04	.08	.09
Usefulness of Math	.31	.52	.41	.47
Effectance Motivation	.34	.51	.35	.46
Mathematics Performance				
Total score on performance scale	.31	.41	.44	.42
ACT Math Score	.34	.58	.57	.61
Sex Role Variables				
Masculinity	.28	.29	.23	.33
Femininity	.01	.01	-.06	.00

Note. For Attitudes towards math and sex role variables, means are based on N=262 for self-efficacy subscale scores and N=255 for total self-efficacy score. For Mathematics performance variables, means are based on N=181 for ACT correlations. Values r of .10, .14, and .20 are statistically significant at the .05, .01, and .001 levels, respectively.

Table 7

Stepwise Regression Analysis for the Prediction of
Science vs Nonscience Continuum Describing College Major Choice

Significant Predictors	B	F	R	R^2 Adjusted
			.62	.36
Mathematics Self-Efficacy Expectations	.24	5.0*		
Sex	-.21	6.7*		
Years High School Math	.21	5.4*		
Math Anxiety	.21	4.3*		

Note. Degrees of freedom for F-values of beta weights were 1, 99; degrees of freedom for F-value of R were 4, 99.

* $p < .05$