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FACTORS LEADING TO GAINS IN MATHEMATICS DURING THE FIRST YEAR OF COLLEGE: AN ANALYSIS BY GENDER AND ETHNICITY*

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This study explored nontraditional associating factors for the accruement of mathematical skills during the first year of college, including the role of factors pertaining to academic and social involvement, student study behavior, student perceptions of the quality of teaching, financial support, and awareness of prejudice. This model employed a unique formula for the calculation of math gain that controlled for ceiling effects and nonlinearity. A nationally representative sample of first-year college students was tested by both gender and ethnicity. Although many of the factors tested contributed to math gains for the entire sample, there were many marked differences when analyzed by gender or ethnicity.

INTRODUCTION

Despite the present era of economic austerity and rising levels of unemployment, the need remains for college-educated workers with appropriate technical and mathematical skills (Hector, 1993; Thompson, 1993). However, numerous studies have shown that U.S. students' performance in mathematics has consistently been substandard, especially in comparison to other industrialized countries (International Association for the Evaluation of Education Achievement, 1987; Ziomek & James, 1995). The inferior performance of U.S. students is especially evident from the results of the congressionally mandated 1990 mathematics assessment performed by the National Assessment of Educational Progress (NAEP). This study indicated that over one third of U.S. high school students performed below even the basic level in mathematics (Baorque & Garrison, 1991). This national situation has initiated remedial mathematics instruction at all educational levels, including at most colleges and universities. Although numerous solutions have been proposed to

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alleviate this situation, the problem continues and does not show signs of cessation. One popular contemporary solution to low mathematics achievement is increased use of technology (Comez, Beery, & Scherer, 1993; Ganguli, 1992; Gordon, 1993; Jones, 1992). Other common solutions include teaching mathematics with a definite and applied focus (Hector, 1993; Lankard, 1993), earlier interventions and the use of remediation (New Jersey State Department of Higher Education, 1986), experimenting with new tutoring formats (Miller & McDermott, 1983; Robertson 1991), and the construction of learning communities (Anderson & Stein, 1992). Although this study sought neither to deny nor to challenge the contemporary solutions of mathematics deficiency or to achieving higher gains in quantitative reasoning, it did seek to explore additional avenues for the accruement of mathematical skills during the first year of college. This supplementary approach included the role of factors pertaining to academic and social involvement, student study behavior, student perceptions of the quality of college teaching, financial support, and awareness of prejudice on mathematics gains during the first year of college. A model of mathematics gain was tested on a nationally representative sample of first-year college students by both gender and ethnicity.

LITERATURE REVIEW

Even though the widespread use of computers and electronic calculators have made college mathematics courses less cumbersome, a high failure rate in undergraduate mathematics courses continues (Wieschenberg, 1994). This situation may indicate that past efforts to increase students' quantitative reasoning ability have been insufficient. Furthermore, excluding math majors, avoidance of mathematics classes is at an all-time high (Wieschenberg, 1994). Although inadequate mathematics performance extends beyond gender and ethnic restraints, it appears to be most intense among female and minority students (Bright, 1983; Ethington & Wolfle, 1984, 1986; Flexer, 1984). Differential mathematics performance of postsecondary students by gender and ethnicity is enigmatic because abundant evidence verifies that young students of both genders and all races begin education with equal potential in mathematics and science performance (Ascher, 1983; Blosser, 1990; Entwisle & Alexander, 1990; Russell & Ginsburg, 1980).

Women

Schmuck and Schmuck (1994) reported that women's math self-esteem steadily erodes beginning in late adolescence. Sax (1994) stated that women's low self-esteem and negative mathematical self-concept was responsible for subsequent college math avoidance. Sax believes that negative mathematical self-concepts most likely develop through childhood and adolescence and are later reinforced in college classes. Negative self-concepts were also cited by Mura (1987), who found women from five Canadian universities underestimated their math grades and had low levels of mathematics confidence.

Trying to comprehend the relationship between math achievement, class environment, and mathematical self-concepts, Brunson (1983) conducted a study at Indiana University comparing mathematical ability scores of women in mixed-sex sections with women in an all-female section. Despite the fact that the women in the all-female section had lower mathematics ability initially, they later outscored the women in the mixed-sex sections. Based on these findings, Brunson (1983) promoted unconventional settings and more gender-friendly atmospheres to encourage mathematical growth in women.

Because mathematical achievement has been generally lower for women than men, it is not surprising that fewer women than men pursue math or science-related careers. However, even among those few women who cross traditional gender lines and venture to technical and/or math- and science-related careers, career persistence has been found to be lower than for their male counterparts (Farmer, Wardrop, Anderson, & Risinger, 1995). Interestingly, Farmer and associates (1995) found that women who have persisted in math-related careers have tended to take significantly more math and science courses than their male counterparts. Another study of female persistence in mathematics found that program persisters had higher self-esteem, better math and science backgrounds, more involvement in extracurricular activities, and positive relationships with faculty (Miller & Silver, 1992).

Minorities

The importance of eradicating the math differential for minorities was outlined by Hayes (1994). She concluded that inadequate mathematics and science achievement was one of the main barriers to professional and medical careers for minority students. Hayes also cited inadequate mathematics preparation, ineffective advising, and nonsupportive faculty as reasons why many minority students have fallen short of their goals.

On the other hand, Anderson (1990) blamed mathematics curricula designed for nonminority students, which may reinforce racial inferiority complexes as one of the reasons why African-American students have tended to score lower in mathematics achievement tests. Anderson promoted a radical pedagogy to bolster minority student's mathematical self-esteem and self-assurance. Along the same lines, Frankenstein (1990) promoted an ethnic-centered mathematical curriculum that she believed would bridge practical and abstract mathematical knowledge, thus increasing mathematical literacy for people of color.

A study conducted at Iowa State University substantiated the need for mentoring minority students to encourage proper study habits, better test-taking skills, and the overall improvement of mathematics performance (Allen-Sommerville, 1992). Anderson (1993) agreed that holistic strategies, including financial programs and quality teaching, should be mandatory to increase mathematical ability among minority students.

Conceptual Framework

Research studies generally focus on mathematics achievement or on general success in college across various ethnic and gender subpopulations (Frary & Ling, 1983; Nora, Cabrera, Hagedorn, & Pascarella, 1994; Nora & Horvath, 1990). These studies have suggested that a variety of factors such as mathematical ability, persistence, anxiety, attitudes, backgrounds, and exposure to mathematics (i.e., number and kind of math classes taken) have been explanatory factors of mathematics achievement (or lack thereof).

The theoretical basis of this study was grounded in numerous studies of college mathematics success (Payzant & Wolf, 1993; Kamii, 1990; Waits & Demana, 1988). The pertinent literature stated that ethnicity, gender, the level of college mathematics, attitudes toward study, and attitudes regarding the quality of college teachers all contribute to gains in mathematical reasoning ability in college. Unique to this study is the exploration of the role of perceptions of discrimination in mathematical gains. Specifically, this study proceeds from the following premises:

1. Contemporary approaches to mathematics remediation can be effective for some students.
2. Despite present efforts, the need for remediation appears persistent.
3. The number of students requiring mathematics remediation is increasing.
4. There is a need to examine external factors that directly or indirectly may be enhancing or depleting mathematical achievement.
5. Approaching mathematics achievement from the perspective of the external environment may provide additional avenues through which mathematics achievement in college can be enhanced.

METHOD

Sample

This study's sample was derived from the National Center on Postsecondary Learning and Assessment (NCTLA) consisting of first-year college students from 23 colleges and universities in 16 states throughout the U.S. All incoming first-year students at participating institutions were invited to participate and were told they would receive a small stipend in reward for their time and honest responses. Participating institutions were purposefully selected from the National Center on Education Statistics IPEDS database to represent differences in colleges and universities nationwide on a variety of characteristics, including institutional type and control, size, and the ethnic distribution of the undergraduate student body. Although this sampling technique cannot be described as random in the purest sense, this stratified method of choosing the 23 participating institutions resulted in a sample that approximated the national population of undergraduates by ethnicity, gender, and institutional type.

The NCTLA began in Fall 1992 with a precollege data collection. Each of the 23 participating institutions was given a target sample size that was calculated in proportion to their first-year enrollment. A 76.8% participation rate was achieved. During the initial data collection, participating students completed the reading comprehension, mathematics, and critical thinking modules of the American College Testing Program's Collegiate Assessment of Academic Proficiency (CAAP). A follow-up testing of the sample took place in the spring of 1993. During this testing, students completed a different form of each CAAP module (reading, math, critical thinking) from that taken the previous fall, the College Student Experiences Questionnaire (CSEQ), and the NCTLA Follow-up Questionnaire. The CSEQ measures student involvement in a range of activities during college, and the NCTLA Follow-up Questionnaire assessed such dimensions as interaction with faculty and peers, types of courses taken, orientations toward learning, the kinds of instruction and teaching received, as well as perceptions of discrimination.

The subsample of respondents used in this study consisted of white, African American, and Hispanic students who took both the math pretest and posttest. A weighting algorithm specific to each participating institution was applied to better represent the ethnic and gender breakdown of the participating institutions. For example, if a specific institution had 400 Hispanic females in the first-year class but only 100 Hispanic females in the sample, each Hispanic female respondent from that particular institution would be given a sample weight of 4.00. The result of the weighting algorithm was a sample size of 16,416. This sample was 52.1% female and 25.4% minority (African American or Hispanic).

Calculation of Math Gain

Both the mathematics pretest and posttest consisted of 35 items. These tests measured the student's ability to solve mathematical problems typical to college curricula while emphasizing quantitative reasoning over formula memorization. The content areas tested include pre, elementary, intermediate, and advanced algebra, coordinate geometry, trigonometry, and introductory calculus. The KR-20 alpha coefficient of generalizability and test reliability for the mathematics test ranged between 0.79 and 0.81.[1] The dependent variable of this study was gain in mathematics from entry into college to the end of the first year as measured by the mathematics CAAP pretest to posttest. Students who did not perform better on the posttest than on the pretest were assigned a gainscore of 0 (less than 7% of the sample).

A problem when studying student gains is that sharp disparities exist between high- and low-scoring individuals with respect to their relative improvements, even though their absolute improvements may be equal. This phenomenon, usually referred to as the ceiling effect, is imposed by the theoretical maxima and minima of the scores. For example, a student scoring 20 in a pretest and 40 in the posttest appears to have an improvement rate of 100%, whereas another student who scored 80 in the pretest and 100 in the posttest would have an improvement rate of 25%. Although both students in this example had very different improvement rates, they both had an absolute improvement of 20 points. Another problem of gain scores is due to the nonlinear nature of gains. Students who score low on the pretest have a higher probability of improvement than students who initially score high. For example, a student who correctly answers 90 out of 100 items in the pretest has a gain margin of only 10 items, whereas the student who correctly answered only 30 items has a gain margin of 70 points.

An appropriate way to deal with these problems is to express pretest to posttest gains relative to the student's maximum attainable gain (P). This relative gain is defined as follows:

$$P = (\text{Post} - \text{Pre})/(\text{Max} - \text{Pre})$$

where Post = posttest score; Pre = pretest score; Max = theoretical maximum gain (i.e., 35-Pretest score). The resulting P is between 0 and 1.

We define the function G as $G = P/(1 - P)$. This function is an "odds" function in the probabilistic sense. When P is small, the function G approximately equals P. In other words, G exhibits complete linear behavior for all values of P near zero. However, as P approaches one, G approaches extremely large values (i.e., G becomes totally nonlinear in the neighborhood of 1). It is easy to see that $0 \leq G \leq \infty$, for $0 \leq P \leq 1$. Applying the natural logarithm to G will thus slow down the growth of the gain near 1, and would linearize it

[1]The KR-20 alpha coefficient of generalizability and test reliability was developed by Kuder and Richardson (1937). Coefficients range from 0 (indicating complete unrealiability) to 1 (indicating perfect reliability).

in this interval. This transformation will also expand the range to all real numbers (i.e., whereas G is restricted to take on only nonnegative numbers, natural logarithm of G can take all negative as well as positive numbers).

Linearizing the student gain scores is particularly important in multiple regression analysis, where linearity of the model requires the dependent variable to be free to assume all real numbers. In the present study, the logit transform linearizes the S curve of the gain, thereby better estimating the parameters under study.

The logit P is defined as the natural logarithm of G: logitP = lnG = ln(P/1–P). Whereas the domain of the logit function is between 0 and 1 (i.e., $0 \leq P \leq 1$) its range sweeps all real numbers (i.e., $-\infty \leq \text{logitP} \leq \infty$). The logit P is perfectly symmetrical at P = 1/2 and has zero value at this point.

Based on the logit transformation, we can use the following linear model for our multivariate regression analysis:

$$Y = \text{logitP} = \sum_{i=1}^{n} \alpha_i \cdot X_i + \varepsilon.$$

Here αi's represent the regression coefficients, X_i's are the independent variables under study, such as academic involvement, prejudice, perceptions of teaching quality, study behavior, etc., and ε the residual, the error term representing the difference between Y and the actual gain. It is assumed that ε's are normally distributed with $\mu = 0$ and $\sigma^2 = 1$.

If the above summation and its residual is denoted by Z, then ln (P/1 – P) = Z. Exponentiating both sides of this expression provides a direct formula for P: $P = e^z/(1 + e^z)$. As Z approaches ∞, P will approach 1, and as P approaches –∞, P will approach 0. When Z = 0, P = 1/2. Figure 1 presents the graph of P as a function of Z. The domain of the function (values of Z on the horizontal axis) extends to all real numbers from – infinity to infinity. The range of the function (values of P on the vertical axis) extends from 0 to 1. The graph of P is a smooth Sigmoid (S-shaped curve) that is perfectly symmetric at (0, ½). The graph satisfied the 0 to 1 constraint on P without restricting the values of Z.

P represents a continuous and increasing function commonly referred to as the "logistic function" (Aldrich & Nelson, 1984). Although there are other alternative approximations such as normal, sine, and Urban's models (Ashton, 1972), the special characteristics of this function make it an appropriate model for this study.

Independent Variables

The 17 independent variables were classified into six blocks. The first block, commitment and math enrollment, consisted of the student's commitment to complete a bachelor's degree, the desire to remain at the present institution, the number of enrolled credit hours, and the type of math taken in the first year of college.[2] The second block, perceptions of

[2]Values for the type of math taken were determined as follows: 1 = enrollment in pre-algebra or arithmetic; 2 = enrollment in algebra or geometry; 3 = enrollment in calculus or statistics; and 4 = enrollment in matrix algebra. Because this study included students from 23 different institutions, it may be assumed that although course content varies by institution, the above structure would satisfactorily classify students by level of mathematical development.

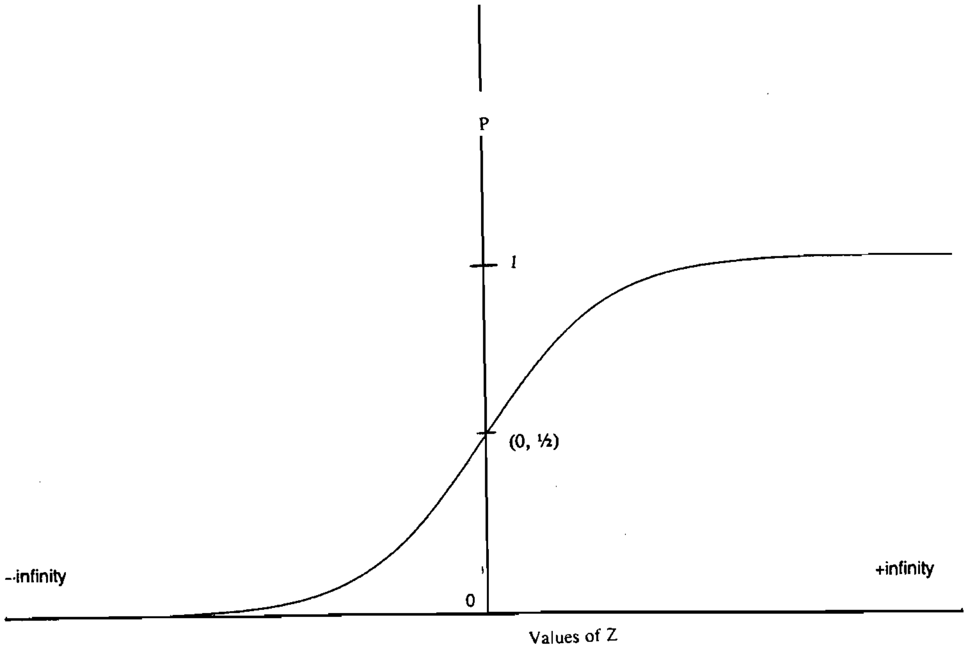

Figure 1. The graph of P as a function of Z. [$P = e^Z/(1 + e^Z)$]

prejudice, consisted of two scales measuring the student's perceptions of the presence of gender and racial prejudice. Perceptions of teaching was the third block and consisted of one scale that measured the student's assessment of the quality of teaching at the institution. The fourth block was labeled study habits and consisted of the self-reported average number of weekly hours spent in study and an item where students reported how often they studied with other students. The fifth block assessed social integration. This block consisted of two dichotomous items identifying athletes and members of Greek organizations as well as a scale measuring student involvement in clubs and organizations. The final block dealt with financial aspects. Included items were the measure of importance of financial aid, the proportion of college expenses provided by parents or family, and three dichotomous variables that classified students as working on campus, working off-campus, and financing their education with loans. Using confirmatory factor analysis, all scales were tested for reliability. Table 1 provides descriptive information of all variables as well as the Cronbach's Alpha for scales.

Initial Analysis

Initial analyses included the monitoring of all variables for excessive skewness or other departures from normality that might violate necessary assumptions of statistical tests. To test for significant differences in math gains by both gender and ethnicity, a two-way analysis of variance (ANOVA) test was performed.

Table 1. Study Variables

Block identifier Variable names	Description	Range	Mean	S.D.
Dependent variable				
Math gain	ln (p/1 – p); where p = (posttest-pretest)/ (maximum score-pretest)	–3.44 to 8.225	–1.418	1.11
1. Commitment and math enrollment				
Institution	Plans to complete the degree at the present institution (0 = No, 1 = Yes)	0 to 1	0.46	0.498
Hours	Number of enrolled credit hours	6 to 24	13.2	5.16
Math type	Type of math enrolled in first year[a]	1 to 4	2.1	1.22
Goal	Commitment to receiving a bachelor's degree (0 = not committed, 1 = committed)	0 to 1	0.4	0.49
2. Perceptions of prejudice				
Gender	Perceptions of gender prejudice scale (9 items; Alpha = 0.9067)	1 to 5.2	2.37	1.10
Racial	Perceptions of racial prejudice (12 items; Alpha = 0.9178)	1 to 5.3	3.33	0.759
3. Perceptions of teaching				
Teach	Perceptions of the quality of college teaching (14 items; Alpha = 0.9067)	1.5 to 4.0	3.07	0.473
4. Study habits				
Friends	Study with other students from class	1 to 4	2.44	0.895
Study hrs	Number of reported weekly hours spent studying	0 to 40	22.1	9.76
5. Social integration				
Athlete	Particpation in athletics (1 = yes; 0 = no)	0 to 1	0.10	0.299
Greek	Membership in a fraternity or sorority (1 = yes; 0 = no)	0 to 1	0.12	0.321
Club	Measure of involvement in college-supported clubs and organizations (9 items; Alpha = 0.9216)	1 to 4	1.88	0.757
6. Financial aspects				
Financial aid	Measure of the importance of financial aid (2 items; Alpha = 0.7984)	1 to 5	3.90	1.212
Work-on	Employed on campus (0 = no; 1 = yes)	0 to 1	0.351	0.478
Work-off	Employed off campus (0 = no; 1 = yes)	0 to 1	0.328	0.470
Expenses	Proportion of college expenses provided by parents or family (1 = all to 4 = none or very little)	1 to 4	2.47	1.23
Loans	Financing education with loans (2 = yes; 1 = no)	1 to 2	1.32	0.123

[a] 1 = remedial classes (pre-algebra or arithmetic; 2 = algebra/geometry; 3 = calculus/statistics; 4 = matrix algebra.

Data Analysis

The factors related to mathematical gains were analyzed through the multiple regression procedure. Because the interaction of gender and ethnicity was found to be not significant in the initial analysis, the performed analyses were (a) males, (b) females, (c) minorities, and (d) nonminorities. The unstandardized regression weights (b weights) were compared across the separate subsamples to determine differential effects. Standardized regression weights (beta weights) were compared within each subsample to discover the relative importance of each of the independent variables. Whenever an independent variable was a significant predictor of math gain for both males and females or both minorities and nonminorities, a t-test of the regression weights was calculated to determine if the variable was a significantly better predictor for one group.

RESULTS

Initial Analysis

For all variables, except membership in a Greek organization and participation in athletics, the absolute value of skewness was less than 2 standard deviations. The skewness of the Greek membership variable and the athletic participation variables was 2.2 and 2.7 standard deviations, respectively. Both of these dichotomous variables were valid representations of the relatively small proportion of students who joined Greek organizations or participated in intercollegiate athletics. Because Pedhazur (1982) stated that "regression analysis is generally robust in the presence of departures from assumptions, except for measurement errors and specification errors," no alterations were deemed necessary to these variables.

The results of the multivariate two-way ANOVA testing for group differences in math gain by gender and ethnicity were significant ($F = 53.539$; $p < 0.0001$). The gender ($F = 23.767$; $P < 0.0001$) and the ethnicity ($F = 76.895$; $P < 0.0001$) main effects were both found to be significant. Because the test for interaction by gender and ethnicity was not significant ($F = 0.395$; $p = 0.556$), the sample was first analyzed by gender and then by minority/nonminority status. Table 2 presents the cell means for the dependent variable. It should be noted that the means in the $\ln(p/1 - p)$ column are in logarithmic units and as such the negative sign of these numbers only indicates that the gains are less than one.

The figures in the column labeled P can be interpreted as the average percentage gains by that particular group. Therefore, whereas males had an average pretest to posttest gain of 22.95%, the female gain was 17.49%. For the analysis by ethnicity, whereas minorities experienced an average of 13.3% gain, nonminority cohort had a 22.29% gain.

Analysis by Gender

The results of the block by block increase in the proportion of explained variance (r^2) of the dependent variable, math gain, is presented in Table 3. Table 3 presents these block

Table 2. Math Gain Cell Means

	ln(p/1 − p)	p/1 − p	p
Gender			
Males	−1.21	0.298	0.2295
Females	−1.55	0.212	0.1749
Ethnicity			
Minorities	−1.87	0.154	0.1334
Nonminorities	−1.25	0.287	0.2229

Table 3. Block by Block R^2 Change

	Males	Females	Minority	Nonminority
Block 1: academic involvement	0.18258*	0.17519*	0.13810*	0.20743*
Block 2: prejudice	0.00664*	0.00889*	0.01638*	0.05409*
Block 3: perceptions of teaching quality	0.00007ns	0.01713*	0.00002ns	0.00058ns
Block 4: study behavior	0.03448*	0.00939*	0.13038*	0.00214*
Block 5: social involvement	0.01829*	0.01645*	0.04843*	0.03273*
Block 6: financial support	0.09699*	0.07717*	0.05730*	0.08550*
Total R^2	0.33905	0.30421	0.39063	0.38245

* $p < 0.01$.

increases for males, females, minorities, and nonminorities. All of the blocks, except perceptions of teaching quality, added significantly to explaining math gain for all four cohorts. Interestingly, positive perceptions of teaching quality significantly predicted math gain only for females.

Table 4 presents both the unstandardized (b weights) and standardized (beta weights) regression coefficients for males and females. The t-value resulting from the test of regression weights when a variable was a significant predictor for both genders is also presented. Within the commitment and math enrollment block, commitment to complete the bachelor's degree at the present institution was a significant positive predictor of math gain for males, but was not significant for females. Full-time enrollment (hours), taking advanced mathematics courses (math type), and commitment to achieving a bachelor's degree (goal) were significant predictors for both men and women. Tests of the regression weights revealed that the number of enrollment hours was a significantly better predictor of math gain for males that it was for females.

Within the perceptions of prejudice block, whereas a gender-friendly environment (gender) was a significant predictor for both genders, an environment free of racial prejudice (racial) was a significant predictor only for males. The perceived quality of teaching (teach), the only variable in the perceptions of teaching quality block, was significant only for females. Within the third block of variables, study habits, studying with friends (friends) was a positive predictor of math gain for males. However, studying with friends was a significantly negative predictor for females. Although the number of reported weekly study hours (study hrs) was a positive predictor for both men and women, it was significantly more predictive of high math gains for males. Among the three variables in the fifth block, social integration, only participation in clubs and organizations (club) was a positive significant predictor for both genders. However, participation in clubs and organizations was significantly more predictive of math gains for females. Although participating in athletics (athlete) was not significant for men, it was a positive predictor for women. On the other hand, although membership in the Greek system (Greek) did not have a significant effect for women, it was a negative predictor for men. Within the last block, financial aspects, the reliance on financial aid was a negative and significant predictor only for men. Working on campus (work-on) was a positive and significant predictor only for men. However, holding a job off-campus (work-off) was a significant and negative predictor for both genders. The proportion of college expenses shouldered by

Table 4. Regression Weights by Gender

Variable	Males		Females		T-test of regression weights
	b weight	Beta weight	b weight	Beta weight	
Commitment and math enrollment					
Institution	0.148056	0.071299*	0.066859	0.029509^{ns}	
Hours	0.062821	0.287111*	0.017658	0.064156*	7.35*
Math type	0.306396	0.332355*	0.296713	0.303979*	0.457
Goal	0.252052	0.123251*	0.273625	0.107326*	0.182
Perceptions of prejudice					
Gender	0.191399	0.208937*	0.197410	0.163939*	
Racial	.0.131344	0.092130*	–0.039776	–0.025610^{ns}	
Perceptions of teaching quality					
Teach	–0.076634	–0.033038^{ns}	0.251333	0.098604*	
Study habits					
Friends	0.062333	0.052720*	–0.121490	–0.101461*	6.75*
Study hrs	0.012299	0.250815*	0.003557	0.120134*	8.84*
Social integration					
Athlete	0.080768	0.027026^{ns}	0.176219	0.051277*	
Greek	–0.279060	–0.085048*	–0.096987	–0.027435^{ns}	
Club	0.118136	0.088621*	0.214152	0.140987*	2.78*
Financial aspects					
Financial aid	–0.149287	–0.185219*	–0.010540	–0.011848^{ns}	
Work-on	0.560058	0.248929*	0.046105	0.019161^{ns}	
Work-off	–0.150626	–0.069795*	–0.209902	–0.092195*	1.98
Expenses	0.051317	0.061903*	0.186640	0.206861*	6.49*
Loans	–0.225019	–0.257391*	–0.300251	–0.298000*	2.47

* $p < 0.01$.

family was a positive predictor of math gain for all, but was even more predictive for females. Finally, relying on loans was a negative predictor for all.

Analysis by Minority/Nonminority Status

The regression weights and results of t-tests for minorities and nonminorities are presented in Table 5. Although all four variables in the commitment and math enrollment block were significant for everyone, higher number of enrolled hours and goal commitment had significantly larger effects for minorities. Enrolling in advanced math classes had a significantly larger effect for nonminorities. The relationship for institutional commitment differed by minority/nonminority status. In this sample, although commitment to finish the degree at the present institution was a significant and positive predictor for nonminorities, it was a significant and negative predictor for minorities.

Within the perceptions of prejudice block, although a racially friendly environment was a positive predictor for all, the lack of gender prejudice was a positive and significant predictor only for nonminorities. Interestingly, the effect of the absence of perceived racial prejudice had a significantly larger effect on the math gains of nonminorities.

Table 5. Regression Weights by Ethnicity

Variable	Minorities		Nonminorities		T-test of regression weights
	b weight	Beta weight	b weight	Beta weight	
Commitment and math enrollment					
Institution	–0.181049	–0.108012*	0.216845	0.096678*	0.69
Hours	0.047067	0.321476*	0.020612	0.064086*	4.34*
Math type	0.054912	0.064949*	0.330173	0.348985*	11.49*
Goal	0.515811	0.298980*	0.195204	0.085934*	6.25
Perceptions of prejudice					
Gender	0.054189	0.046579^{ns}	0.646602	0.440056*	
Racial	0.228073	0.244569*	0.540966	0.338042*	5.35*
Perceptions of teaching quality					
Teach	0.244712	0.137565*	0.126329	0.047994*	1.97
Study habits					
Friends	–0.429015	-0.461997*	0.031131	0.024440^{ns}	
Study hrs	0.002140	0.090416*	0.002329	0.078845*	0.277
Social integration					
Athlete	0.181846	0.046826^{ns}	0.038379	0.011921^{ns}	
Greek	–0.027964	–0.010127^{ns}	–0.199483	–0.058825*	
Club	0.349726	0.335059*	0.195468	0.130028*	
Financial aspects					
Financial aid	–0.093486	–0.123929*	–0.133149	–0.161717*	1.55
Work-on	0.114486	0.068299^{ns}	0.367671	0.153122*	
Work-off	0.283193	0.173995*	–0.369509	–0.160373*	
Expenses	-0.003071	–0.004652^{ns}	0.217934	0.236600*	
Loans	–0.356843	–0.216747*	–0.082153	–0.035911^{ns}	

* $p < 0.01$.

The single variable in the perceptions of teaching quality block was a positive and significant predictor of math gain for all. The number of reported weekly study hours, in the study habits block, was a positive and significant predictor for both minorities and nonminorities. Studying with friends, however, was not significant for nonminorities, but was negative and significant for minorities.

The only variable in the fifth block, social integration, that had a significant effect for all was membership in clubs and organizations. This variable had a significantly larger effect on minorities. On the other hand, participation in athletics was not significant for all. Membership in a Greek organization was not significant for minorities, but was a significant and negative predictor of math gain for nonminorities.

Within the last block, financial aspects, the reliance on financial aid was a significant and negative predictor of the dependent variable for all. Although working on campus did not have a significant effect on math gain for minorities, it had a positive and significant effect for nonminorities. Although working off campus was a significant and negative predictor for nonminorities, it was significant and positive for minorities. Having a large proportion of expenses paid by family had a positive and significant effect only for nonminorities. Although financing education through loans did not have a significant effect for nonminorities, it was a negative and significant predictor for minorities.

DISCUSSION

Although many of the determinants of math gains for the first year of college differ by gender and ethnicity, measures of commitment and enrollment in higher-level mathematics courses was found to best explain gains in mathematics for all first-year students in this study. This finding supports the importance of establishing an appropriate high school mathematics foundation for all college-bound students. An interesting link between first-year math gains with both full-time college enrollment and commitment to completing the degree was also found for all students, suggesting that serious students who can reduce outside interruptions or "pull factors" may increase mathematical cognitive gains. Perhaps the nature of mathematics makes it difficult to "squeeze" studying or homework into a schedule already full with noncollege responsibilities, such as employment or family obligations. Studying mathematics generally requires long uninterrupted periods that may be difficult for the part-time student to manage.

It is indeed interesting to note that an environment perceived to be free of both racial- and gender-related prejudices had positive implications toward mathematical gains for most students. Perhaps it should come as no surprise that the elimination of animosity and promotion of harmony not only encourages institutional satisfaction but may also encourage learning.

Gender

Clear differences between males and females occurred with respect to study habits. Whereas studying with friends apparently contributed to math gains for males, group study appears to hinder these gains for women. Without a qualitative portion to this study, definite conclusions cannot be stated; however, one may contemplate that this divergence may be due to the smaller number of women in mathematics. It may be that women studying in predominantly male study groups are not participating as full members, or that some women are uncomfortable studying within predominantly male groups, opting instead for more limited all-female opportunities. Again, this difference may be due to the nature of mathematics. Problem solving, developing proofs, graphing, and other activities associated with understanding mathematics may be best achieved by women through personal study rather than group participation.

Although males are also affected by the teaching skill of professors (Pascarella, Edison, Nora, Hagedorn, & Braxton, 1996), this study indicates that teaching skills may be even more important to the cognitive gains in mathematics for females. This finding underscores the importance of faculty of all disciplines, but perhaps even more so for mathematics, of maintaining quality teaching methods and innovative classroom techniques. Because previous studies have found women shortchanged with respect to wait time, number of directed questions, and overall instructor attention, some researchers are calling for female-only mathematics classes (Brunson, 1983; Ransome, 1993; Steinback & Gwizdala, 1995). Although the efficacy of female-only mathematics classrooms was not assessed by this study, the findings do offer fertile ground for future research.

Perhaps most interesting is the role of different aspects of social involvement for males and females. Participating in sports and college-related clubs had significantly higher gains in first-year mathematics for women. This finding indicates that women who are actively involved in their institution are more likely to achieve higher gains in mathematics. The finding that participating in fraternities negatively affects math gains for males, while sorority membership has no effect for women, adds to the burgeoning argument against Greek organizations recruiting undergraduates in the early years of college (Pascarella, Edison, Whitt, Nora, Hagedorn, & Terenzini, 1996). Apparently, early fraternity activities may detract from important mathematics gains for males. Because the subject matter of mathematics is cumulative, early deficits may be very difficult, if not impossible, to counteract.

Although financial aspects affected the math gains of both men and women, some differences are worth noting. For instance, although the need for financial aid was a negative predictor of math gains for all, it was even more of a detriment for males. Moreover, working on-campus had a positive and significant effect on math gains only for males. These two findings in tandem indicate that on-campus employment may be a positive way to provide financial aid, especially for male students.

Ethnicity

The analysis by ethnicity revealed many differences between minority and nonminority students. Full-time enrollment and high goal commitment were found to be especially important to the mathematical gains of minority students. These findings emphasize the need for the institution to assist students to reduce "pull factors" that have been found to compel minority students to enroll part-time and to assign a subordinate importance to timely degree completion (Nora, Cabrera, Hagedorn, & Pascarella, in press).

The findings regarding perceptions of prejudice offer interesting interpretations. Although a racially friendly environment encouraged math gains for all, it was especially important for nonminorities. This finding must be carefully interpreted because conclusions can only be made about the minority students who despite previous racial obstacles have enrolled in college. It may be that although this sample of minority students have become somewhat hardened to a "cool climate" many of the nonminority students may be encountering challenges to diversity for the first time. However, when coupled with the finding that only nonminorities had significant ties between math gains and positive gender-friendly environments, one is led to believe that an analysis by both gender and ethnicity may answer some of these questions. Also helpful would be a follow-up qualitative component to delve into the nature of these relationships. However, whatever the reasons for these findings, it is clear that college administrators and faculty must continue to eliminate all vestiges of prejudice for numerous reasons, including the promotion of positive academic gains for all students.

Group study was found to negatively affect the math gains of minority students. Similar to the situation for females, minority participation in mathematics has been found to be very low (Anderson, 1990; Hayes, 1994). Therefore, this sample of minority students may feel uncomfortable in primarily nonminority study groups. One answer to this situation may be in the creation of more learning communities such as those created at Montana State University's American Indians in Mathematics (AIM) project. Montana has reported significant math gains among native American students through this special program designed to focus mentoring and create learning communities of minority students (Anderson & Stein, 1992).

There are several implications arising from the differences found in social integration between minority and nonminority students. Specific differences were, although Greek affiliation had a negative effect for nonminority students, the effect was not significant for minority students; although active participation in clubs had a positive effect on math gains for all, it was significantly more for minorities. These two findings suggest that social integration may be a very important ingredient for cognitive gains in mathematics for minority students. Because other studies have found that social integration among minority students encourages college retention, active participation should be especially advocated among minority students (Castle, 1993). However, institutions must do more than advocate; they must provide the appropriate means for integration. In many cases, minority students need the kind of social support that can be provided through Black or Hispanic fraternities, sororities, or other special dedicated clubs or organizations. However, when providing the means for healthy separation, institutions must be careful not to cross the line into unhealthy separatism (see Hasegawa, 1991).

For both minorities and nonminorities, having to rely on financial aid was a negative and significant predictor of math gains. This finding was anticipated. However, for minority students many of the other findings among the financial aspect variables were not as anticipated. For instance, for this sample of minority students, although working on-campus had no effect, working off-campus appeared to have a positive and significant effect on math gains. Working off-campus generally pulls one away from studying and has a detrimental effect. But among the minority students in this sample, working off campus did not seem to affect them as anticipated. It may be that the minority students who worked off-campus were mature enough to be able to juggle both working and appropriate study time. Or, it may be that students who were not having academic problems felt free to pursue outside employment. Whatever the reasons, among this sample 40% of all minority students reported some form of outside employment compared with only 28% of the nonminority students.

Final Words

Cognitive gains have many antecedents. Certainly background, ability, and one's academic record play an important role in cognitive development during the first year of college. But, this study dissected gains somewhat differently. Instead of looking at math gains from a strict academic viewpoint, the effect of commitment, perceptions, integration, and financial aspects were examined. This study provides evidence that these factors also play a role in the acquisition of math gains during the first year of college.

This study adds just one more reason to the existing myriad of why colleges must divest themselves of all appearances of discrimination. The revelation that discrimination may limit academic gains of all students regardless of gender or ethnicity has far-reaching implications. Negative environments for students may limit their academic success and therefore have lifelong implications. Because one of the criteria for entrance into graduate school (and hence many professions) is the quantitative score on the GRE or equivalent graduate admissions tests, the need to develop math reasoning ability for undergraduate college students is an obligatory responsibility.

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