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ABSTRACT

This study aims to contribute to the existing research exploring differences in mathematics achievement at the postsecondary level between males and females and minorities and non-minorities. This report explores and expands upon research that documents both cognitive and non-cognitive factors which facilitate or hinder mathematics achievement. The sample which serves as the data for this study is derived from the National Center on Postsecondary Learning and Assessment (NCPLA). Initial statistical procedures included testing all variables of interest for normality, factor analysis to isolate and identify appropriate scales, subsequent tests for construct reliability, and tests for interactions by gender, ethnicity, and remedial/non-remedial mathematics placement. The analysis indicates that non-remedial students in this sample have parents with a higher education, come from families with a higher total income, received more encouragement to pursue higher education, and reported spending more time studying in high school. Contains 48 references. (DDR)

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SUCCESS IN COLLEGE MATHEMATICS: COMPARISONS BETWEEN REMEDIAL AND NON-REMEDIAL FIRST YEAR COLLEGE STUDENTS

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SUCCESS IN COLLEGE MATHEMATICS: COMPARISONS BETWEEN REMEDIAL AND NON-REMEDIAL FIRST YEAR COLLEGE STUDENTS

Introduction

The popular press is replete with reminders that the mathematics achievement of U.S. high school students lags behind that of other industrialized countries (Briscoe, 1995; Cipra, 1993; Hancock & Wingert, 1995; Report Card, 1991). Recently, the Los Angeles Times revealed that despite the California State University system's policy of accepting only students from the upper half of their graduating class, over half of the entering freshmen were unprepared for college level mathematics (Weiss, March 20,1997). Further proof comes from the largest, most comprehensive, and rigorous international comparison of international student achievement which recently substantiated the continued substandard mathematical performance of U.S. students. The Third International Mathematics and Science Study (TIMSS) tested the math and science knowledge of over a half-million students from 41 nations at five different grade levels. At this time, information for only eighth graders has been released, but it clearly indicates that U.S. students scored below the international average (Pursuing Excellence, 1996). In the words of the report, "Compared to our goal of excellence among nations, we are not where we aim to be" (Pursuing Excellence, 1996, p 69). The significance of this situation was also clearly portrayed by the national mathematics report card presented by the National Assessment of Educational Progress (NAEP). The nation's report card indicates that less than 20% of U.S. high school seniors perform at a mathematically advanced level and less than 3% exhibit what can be termed superior mathematics performance (Bourque & Garrison, 1991). Collectively these facts explain why over 40% of U.S. first year college and university calculus students fail the course (Wieschenberg, 1994).

Juxtaposing the poor mathematical performance of students with the skills necessary to function in the workplace such as problem-solving and analytical reasoning aptitude, appropriately frames our problem; the U.S. is facing a serious mathematical readiness deficit among present and future workers.

Differences by gender

The problem is complex. Males continue to out perform female students in geometry and measurement, while females out-perform their male counterparts in numbers and operations (Dossey, 1988). Although the mathematical gender gap is slowly disintegrating, the reasons for its existence remain elusive. Researchers attempting to isolate gender differences in ability have found only small differences (Becker, 1990; Benbow, 1988; Feingold, 1988; Zeidner, 1990). Most studies attempt to attribute gender differences to socialization practices rather than innate ability. For example, Tarvis (1992) and Sax (1994) have proposed that gender differences in mathematics ability are due to lower self-esteems that were bruised early in childhood by consistent and pervasive messages of women's intellectual inferiority. Other studies suggest that women avoid mathematics because of its characterization as masculine (Ehrhardt & Sandler, 1987) or because parents and teachers have encouraged girls to excel in more traditional areas for females (Jacobs & Eccles, 1985; Campbell, 1986; Andrews, 1989). Another explanation for the gender gap may be that women and girls are dissuaded by "chilly climates" found in mathematics classes (Pascarella, et al., 1996). This explanation is supported in studies of women who have entered male dominated fields such as engineering. Hewitt and Seymour (1991) reported that female engineers complained of daily irritations and sexist comments from male colleagues as well as frequent innuendo suggestive of the inherent mathematical and scientific inferiority of women.

Differences by ethnicity

Although the mathematics performance gap between non-minority students and African American and Hispanic students has recently narrowed, substantial differences still remain (Dossey, 1988; Manzo, 1994). Studies have linked the low mathematics achievement of minority students to a lack of opportunities and/or differential attitudes practiced by teachers (Ascher, 1983). Evidence of the racial gap in mathematics was recently substantiated by the ACT Assessment Test, a curriculum-based achievement test measuring higher order thinking skills in four core areas. The ACT Assessment Test, which is annually administered to approximately 1,500,000 high school juniors and seniors, found African Americans to be the lowest achieving group, with Hispanic achievement only slightly better (Ziomek & Maxey, 1995). Although scores of the Scholastic Aptitude Test (SAT) confirm this pattern, care must be exercised in interpreting these scores because minority students are taking the SAT in larger numbers which may cause a downward pressure on scores (Manzo, 1994).

Remediation

A common remedy to the problem of matriculating students that are unprepared for college work is enrollment in remedial courses. A shocking 46% of U.S. college students who have earned more than 10 credits are enrolled in at least one remedial course (i.e., English, mathematics, and/or study skills) (Adelman, 1995). Remedial courses are offered in 64% of all four-year colleges, 90% of community colleges, and 91% of public colleges (Mansfield, Farris, & Black, 1991). This situation represents a more than 30% increase from the 1970s level (Dossey, 1988). But just how effective is all of this remediation? Can colleges and universities reverse a trend of failure and prepare students for success in mathematics courses? A snapshot of the present situation of remedial mathematics college students leads us to believe that remediation in its present form is not successful. According to Adelman (1995), the mathematical grounding of many remedial college students is so deficient that a high failure rate exists *even* in the remedial classes. And, this failure rate is disproportionately higher among female and minority students (Melange, 1988). Moreover, the major proportion of these students become frustrated with curriculums that include no true or transferable college credit and therefore "drop out" of college without earning a degree (or in many cases, any transferable college credits). This cycle of non-success is costly not only to the students who forego time, wages, and dreams, but since the majority of remedial coursework is offered in public community colleges (Apling, 1993), expenses are diverted to taxpayers who subsidize public education.

It is evident that high schools graduate a large number of students unable to begin college-level mathematics and colleges struggle to deliver appropriate remedial mathematics instruction (Sagher & Siadat, 1996). This study identified differences between first-year college students enrolled in remedial mathematics from their counterparts enrolled in college-level math. Consistent with the literature, this study defined any mathematics course below the level of calculus as remedial (Adelman, 1995; Sagher, & Siadat, 1996). More specifically, this study tested the relationship between high school variables, first-year college variables, and subsequent college mathematics achievement of remedial and non-remedial students. We examined a threefold research question; what is the relative importance of: 1) demographics (gender, ethnicity, SES), 2) high school academic variables (i.e., type of math taken, GPA), and 3) college-related variables (i.e., student attitudes towards study and quality of college teaching) in predicting math achievement in the first year of college enrollment? All three of these questions were investigated for both remedial and non-remedial mathematics students.

Conceptual Framework

This study adds to the existing research exploring differences in mathematics achievement at the postsecondary levels between males and females and minorities and non-minorities. Specifically, this research explores and expands the findings of Hagedorn, Siadat, Nora, and Pascarella (1996) which documented both cognitive and noncognitive factors that facilitate or hinder mathematics achievement. Hagedorn and colleagues found significant differences in the levels of gains in mathematical achievement between males and females and minority and nonminority students during the first year of college. Furthermore, this study was also grounded on the work of Payzant and Wolf (1993), Kamii (1990), and Waits and Demana (1988). These studies have found that high school academic achievement (GPA), ethnic background, gender, the level of college mathematics, attitudes towards study, and attitudes toward the quality of teaching, affect success in college mathematics.

Research Design

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 country. Institutions were selected from the National Center on Education Statistics database (IPEDS) 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. In aggregate, the student population of these 23 schools approximated the national population of undergraduates by ethnicity and gender.

The NCTLA began in Fall 1992 with a precollege data collection. During the 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 modified form of each CAAP module (reading, math, critical thinking) taken the previous Fall, the College Student Experiences Questionnaire (CSEQ), and the NCTLA Follow-up Questionnaire. The CSEQ measured 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, and the kinds of instruction and teaching received. This study uses the responses of students who completed both the initial and follow-up questionnaires, and the mathematics CAAP test.

Data Analysis. Initial statistical procedures included testing all variables of interest for normality, factor analysis to isolate and identify appropriate scales, subsequent tests for construct reliability, and tests for interactions by gender, ethnicity, and remedial/non-remedial math placement. Based on the significance of the test for interaction by remedial versus college-level math placement, the sample was split into two groups. A oneway ANOVA was performed to identify areas in which the two groups differed. Finally, the parameter estimates for the hypothesized model for each of the two groups were estimated through the software package, Gemini. The Gemini program, written by Lee M. Wolfle and Corinna A. Ethington, analyzes recursive structural equation models and provides standard errors for both direct and indirect effects. The coefficients of determinations and effects (direct, indirect, and total) for both groups were analyzed and compared.

Results

Descriptive analysis.

The final sample included 852 students enrolled in remedial mathematics (i.e., mathematics courses below the calculus level) and 928 in college level mathematics. In terms of gender and ethnicity, 41.2% of the males, 49.9% of the females, 40% of the white, and 57.4% of the minority students were enrolled in remedial mathematics courses. With respect to institutional type, 84.9% of the community college sample and 42.4% of students from four-year institutions were enrolled in mathematics classes with ability levels below calculus.

Factor analysis identified factors representing relationships among the items under study. All scales proposed to represent different factors were tested for reliability (Cronbach's Alpha) and appropriately constructed to reduce measurement error. Our resulting model consisted of 12 constructs. Table 1 presents the items and scales used in the model.

Insert Table 1 About Here

We hypothesized a model of math achievement consistent with our conceptual framework. Three exogenous constructs were hypothesized. Parents' education consisted of the mean of two items which asked respondents about the educational level of their parents (1= grammar school or less to 9= professional degree or doctorate). The alpha coefficient for this scale was .7646. In situations where students reported only one parent, the educational level of this single parent was used. In addition to parents' education, two dichotomous variables, gender and ethnicity were also hypothesized to have an effect on both intervening variables and mathematics achievement. Ethnicity was dichotomized such that White students were coded with 0 and African-American and Hispanic students were coded 1. Students of other ethnic backgrounds were not included in the analysis. The coding for gender was 0 for males and 1 for females.

There were nine endogenous variables in the model. SES was a single variable that reported the range of family annual salary from 1 (less than $6000) to 14 ($150,000 or more). Racial composition of the student's high school and neighborhood consisted of two questions regarding the racial composition of the high school attended as well as the neighborhood where the respondent lived (1=all minority students to 5=nearly all White students). The reliability coefficient for this scale was .8170. Encouragement to go to college was a three item scale (alpha = .6152) that was a composite of the encouragement from family, teachers and counselors, and friends. High school study was a single item which consisted of the student's self-reported number of weekly hours spent studying while a high school student. The last of the high school variables was a single item, HSGPA or self-reported high school grade point average (6=A; 5=A-, B+; 4=B; 3=B-, C+; 2=C, C-; 1=D+ or lower).

The remaining three endogenous constructs were related to college and college experiences. Perceptions of teaching was a scale consisting of 14 items that assessed the student's overall evaluation of the teaching performed by classroom professors during the respondent's first year of college (alpha = .9203). The items in this scale included the student's assessment of faculty organization, use of class time, use of review and explanations, providing appropriate challenge, and use of classroom examinations. Math type was a single item that categorized the type of mathematics taken during the first year of college. Since the NCTLA questionnaire did not include questions on the particular math courses taken in high school, this construct also acted as a proxy for the extent of math taken in high school. Students reporting no math enrollment during the first year of college were dropped from the analysis. The variable math type was coded as 1 for students taking pre-algebra or arithmetic, 2 for students taking algebra or geometry, 3 for students enrolled in calculus or statistics, and 4 for students in matrix algebra. College study habits were assessed through a three item scale (alpha=.7989) that measured the extent of studying in collaborative groups or with friends.

The final variable in our model was math achievement. Math achievement was the score achieved on the mathematics CAAP module taken at the end of the first year of college.

Interactions. We performed separate tests for moderated relationships (interactions) by gender, minority status and remedial/non-remedial math enrollment. We constructed cross products between all independent variables and gender, minority status, and remedial/non-remedial math enrollment. Using a multiple regression approach, the dependent variable, math achievement test score, was regressed on all independent variables resulting in an r^2 of .487. Entering the block of cross products by gender increased the r^2 to .493. This change in r^2 (.006) was not significant ($f=2.011$, $p>.01$). Using a similar process, the addition of cross products by minority status to the equation resulted in an r^2 change of .011. Although this block explained only an additional 1.1% of the variance, it was statistically significant ($f=3.888$, $p<.0001$). Finally, a block of variables containing cross products by remedial status were added to the regression equation with a resulting r^2 change of .035. Thus, the addition of the remedial/non-remedial block of interaction terms explained an additional 3.5% of the variance and was significant ($f=12.011$, $p<.0001$).

The tests of interactions indicated possible moderated relationships between students enrolled in remedial and non-remedial math courses as well as between minority and non-minority students. We initially split the sample by remedial/non-remedial placement. To test for the necessity of sub-dividing the two subsamples by minority/non-minority status, we tested the two subsamples (i.e., remedial and non-remedial) for interaction by minority status. Using an identical procedure as earlier described, we added the block of minority interaction terms to the prediction variables for each subsample. For non-remedial students, the r^2 increased from .305 to .321 with the addition of the interaction terms. This .016 increase was not significant ($f=2.284$, $p>.01$). Similarly, for remedial students, the r^2 increased from .256 to .275 with the addition of the interaction terms thus yielding an r^2 change of .019 that was also not significant ($f=2.138$, $p>.021$). Based on these tests of moderated relationships, the original sample was divided only into students enrolled in remedial mathematics and those enrolled in college level mathematics for all further analysis.

Differences between remedial and non-remedial students. We performed two tests to explore the differences between remedial and non-remedial students. To test for equivalency in gender and minority status, we performed a Kruskal-Wallis test[1]. The results indicated that the remedial group consisted of significantly more women ($\chi^2=13.602$, $p<.0001$) and minority students ($\chi^2=52.674$, $p<.0001$). To explore differences on the other 9 variables in our model, we performed a oneway ANOVA test. Using an alpha of .05, all 9 tests were statistically significant and indicated that non-remedial students in this sample had a) parents with higher education, b) came from families with higher total income, c) received more encouragement to go to college, d) lived in neighborhoods and attended high schools that were predominantly non-minority, e) reported spending more time studying in high school, f) had

[1] Since gender and minority are dichotomous variables, the nonparametric Kruskal-Wallis test was used. The Kruskal-Wallis is the nonparametric equivalent to a oneway ANOVA.

higher high school grade point averages g) reported higher levels of cooperative study in college, h) perceived the level of college teaching to be higher, and i) had higher scores on the math achievement test. Tables 2a and 2b contain the descriptive results of these comparisons.

Insert Tables 2a and 2b About Here

Test of the math achievement model

Since the test for interaction by gender and ethnicity was not significant, these variables were included in the model of study. The hypothesized model is presented in Figure 1.

Insert Figure 1 about Here

Direct paths

Direct paths were hypothesized from parent's education to SES and high school study habits. The path to high school study habits was based on studies which found the academic achievement of parents to be related to academic habits of children (Astone, & McLanahan, 1991; Hein & Lewko, 1994). We hypothesized direct paths from gender to 1) perceptions of teaching, 2) high school study habits, 3) type of math course, 4) college study habits and 5) encouragement to go to college, based on numerous studies reporting gender differences in academic variables (Adelman, 1995; Sax & Antonio, 1995; Stage & Kloosteman, 1995).

Direct paths were hypothesized from ethnicity to racial composition of high school and neighborhood, high school study habits, and math enrollment based on studies finding differences in background variables and academic environments experienced by many minority students (Mansfield, Farris, & Black, 1991; Manzo, 1994).

Direct paths were not hypothesized from either gender or ethnicity to math achievement even though numerous studies have found an apparent link between these constructs. We did not include these paths because young students begin with equal math potential (Ascher, 1983; Blosser, 1990; Russell & Ginsburg, 1980) we hypothesized that the relationship must be indirect and not directly attributable to gender or ethnicity. In addition, we hypothesized direct paths from family income to high school study habits, high school grade point average, and racial composition of the high school and neighborhood (Fadem, et al, 1995; Teachman, 1996). From racial composition of high school and neighborhood, direct paths were hypothesized to high school study habits, perceptions of teaching, math enrollment, and math achievement. These paths were based on studies that have found links between schools with high proportions of racial minorities and lower quality of educational experiences (Kozol, 1991; Mansfield, Farris, & Black, 1991; Waxman, & Padron, 1995).

High school variables. Because encouragement to attend college has been found to bolster academic interest (Grissmer et al, 1994), it was believed that parental encouragement with respect to attending college would positively impact the study habits of students both in high school and college. High school study habits were expected to directly affect high school GPA and the type of math course the student enrolled in upon entering college. Since higher achieving students report higher levels of satisfaction with their educational experiences (Brophy, 1986; Gibbs, 1995), it was believed that high school GPA would also influence the perceptions of the instruction students received in college. For reasons that are self explanatory, we hypothesized a path from high school GPA to type of college math enrollment.

College variables. With respect to college variables, we hypothesized direct paths from perceptions of teaching to math achievement assuming that positive perceptions of teaching would lead to gains in achievement (Brophy, 1986; Gibbs, 1995), as well as from math enrollment and college study habits to math achievement, because higher levels of math and better study habits should yield higher achievement scores.

Coefficients of determination and path coefficients. The coefficients of determination (or R^2) for each structural equation are presented in table 3. The coefficient of determination for the complete model was .305 for non-remedial students and .256 for those with remedial math placements. Also presented in Table 3 are the path coefficients (β weights) for each hypothesized link in both models. For each specific path that was significant for both remedial and non-remedial students, we performed a t-test of the unstandardized regression weights (b weights) to determine if the path coefficient was significantly different between the two groups.

Insert Table 3 About Here

Direct effects. We found that the direct path from racial composition of high school and neighborhood to math achievement was significant for all students thus indicating students from predominantly non-minority high schools and neighborhoods had higher math achievement scores. We found this relationship, however, to be significantly stronger for the non-remedial students. There was a significant positive path from math enrollment to math achievement only for the remedial students thereby indicating that the lower the level of courses taken, the lower the achievement.

Since the path from gender to perceptions of teaching was significant for all students, it appears that women perceive the quality of teaching in a more positive light than their male counterparts. This is consistent with other studies that have found women reluctant to report dissatisfaction when being queried in a general sense. However, when questions are directed at specific areas, occurrences, or environments, the dissatisfaction among women is apparent (Pascarella, et al. in press; Tack & Patitu, 1992). In other words, although women reported higher levels of satisfaction with respect to college teaching in general, care must be exercised in the interpretation of this finding.

The paths to college study habits presented interesting findings. Positive high school study habits yielded strong college study habits for all students, but this relationship was even stronger among the remedial students. However, this finding must be coupled with that from the oneway ANOVA; the mean time spent in study for remedial students was significantly less than that reported by non-remedial students. The path from encouragement was significant only for remedial students, while the path from gender was significant only for those in non-remedial mathematics placements.

Two paths to math enrollment were significant only for remedial students; high school GPA and gender. These paths signified two points for remedial students, (1) poor grades generally led to enrollment in low ability courses and, (2) among remedial students, women tended to enroll in the lowest ability courses.

Students who reported more study time in high school and/or came from higher income homes were more likely to have better high school grades. However, for remedial students, the relationship between high school study and subsequent grades was significantly stronger than for the non-remedial students.

While encouragement to go to college and being female led to positive high school study habits for all, family income's relationship to high school study was moderated by remedial/non-remedial status. Although higher family income led to more positive high school habits for non-remedial students, among remedial students higher family income led to less positive study habits. The relationship between parent education and high school study was significant in a negative direction for non-remedial students only.

As anticipated, paths from income and ethnicity to racial composition of high school and neighborhood were significant for all, indicating that non-minority students and those from higher income families were more likely to live in neighborhoods and attend high schools that were predominantly White. We also found that regardless of remedial or non-remedial status, female students received more encouragement to go to college and higher levels of parent education led to higher family income.

Indirect effects. All hypothesized indirect effects to the dependent variable, math achievement test scores, were not significant for remedial students. Among the non-remedial students:

- income exhibited a significant indirect path predominantly through racial composition of high school and neighborhood;
- minority status indirectly led to higher math achievement predominantly through type of math enrollment; and
- higher levels of parent education led to higher math achievement predominantly through SES and racial composition of high school and neighborhood.

Discussion, Policy Implications, and Conclusions

Differences between remedial and non-remedial mathematics students

Although the tests for differences (Kruskal-Wallis and ANOVA) between remedial and non-remedial math students may not have yielded surprising results, the fact that on *every* test non-remedial students were in a more favorable position requires more attention. For this sample, students in remedial math placements were more likely to come from families with lower incomes, lower educational levels, and receive less encouragement to enroll in college. With the exception of encouragement, institutions have absolutely no control over any of these variables. Although it cannot be inferred that students performing at a less than desirable level in high school necessarily receive less encouragement from teachers and counselors, educational professionals must take care not to preferentially encourage good students at the expense of others. Since more students in remedial placements had graduated from high schools with greater proportions of minority students, interesting implications arise. It may be that the quality of education that students receive in high schools with a larger number of minority students is not equal to that provided in predominantly White high schools. In addition, students in high schools that have high minority enrollments may not be receive the same encouragement from counselors to enroll in higher levels of high school mathematics.

Our finding that students in remedial placements reported studying less in high school, had lower reported grade point averages, and studied less collaboratively in college may also have interesting antecedents. Of course, we cannot infer that remedial students studied less because they were assigned less homework. Nor can we assume that the remedial students reported less collaborative study habits in college because they were not taught these skills in high school, but these findings do indicate the importance of stressing and teaching appropriate study habits in high school. High school teachers should assign outside study and tasks to all students to ensure that students enrolled in lower level math classes are not being short-changed.

Our findings regarding the perceptions of college teaching also present interesting implications. Just why do non-remedial students perceive the quality of instruction to be better than that perceived by the remedial students? One possibility is that non-remedial courses are frequently assigned to the more experienced, preferred, or qualified professors and instructors while remedial-level courses are taught by the less experienced. Or, it could be that college professors and instructors do not perform equally well at presenting less challenging material or may become bored with introductory materials. These findings have implications regarding the quality of remedial curriculums as well as instructor assignments.

Despite recent trends to encourage women and minority students to take more and higher levels of mathematics, we found overrepresentation by women and minorities in college remedial math classes. The antecedent implications of this finding are somewhat clear. Women and minorities are not taking the kind of math in high school that will allow them to start the first year in college at a true college level placement. The reasons behind this conclusion, however, are less clear. We do not know if women and minorities persist in enrolling in lesser ability classes due to differential attitudes of teachers and counselors that have resulted in less achievement for some, lack of opportunities, "chilly climates", or because of societal pressure in general. But, regardless of the specific underlying cause, high school personnel must take the impetus and provide opportunities and encouragement to insure that all students, regardless of gender or ethnicity are enrolling in higher level mathematics courses.

In short, the results of our tests of differences present a clear picture of advantage for students enrolled in college level mathematics. The ground is not level. Students enrolling in remedial mathematics classes are starting our postsecondary institutions at a marked disadvantage. Although college professionals must strive to intervene and help reverse the cycle of inferiority reported by our remedial students, their efforts are ex-post facto.

Conclusions from our model

Our model allows numerous implications and conclusions. One of our more startling findings was the scarcity of significant direct effects on our dependent variable, first-year math achievement. While four of our hypothesized constructs for non-remedial students exhibited significant total effects, only two hypothesized constructs were significant for remedial students. And, with the exception of racial composition of high school and neighborhood, the significant constructs were different for the two groups. In addition, for non-remedial students, higher income, non-minority status, and having parents with higher education led to higher levels of math achievement. For remedial students, higher levels of high school math was the only significant construct in addition to racial composition of high school and neighborhood. With the exception of math enrollment for remedial students, all of these constructs are beyond the power of the institution to alter. However, taken holistically, a troubling picture emerges. It appears that students from higher socioeconomic backgrounds may be receiving a better grounding in mathematics than their less affluent counterparts. It also points to a correlation between high school quality and proportion of the student body that is minority. It is not news that schools in low socioeconomic and/or predominantly minority areas may not be delivering the same quality instruction as schools in more affluent areas. New policy, therefore, is drastically needed to upgrade the instruction provided to our more needy students. We are not inferring that teachers in these schools are either inferior or lackadaisical in method, but rather that the job is differentially more arduous when dealing with students who come to school from backgrounds that are less conducive to learning. Furthermore, many schools in low socioeconomic areas lack the appropriate funds for quality textbooks, technology, and experiential learning. State officials must be informed or reminded of this situation, and parents, teachers, administrators should actively seek opportunities to voice disapproval of this situation.

Other interesting findings can be gleaned from our model. It is interesting to note that regardless of math enrollment, women reported spending more time studying while in high school, perceived higher levels of encouragement to go to college, and perceived the quality of college teaching as better than males in our sample.

We also found that regardless of math enrollment, students who spent more time in study while in high school were more inclined to adopt collaborative study habits in college. Surely the link between positive study habits in high school and subsequent positive study environments in college is intuitive. However, we found that this link was statistically stronger for the non-remedial students. Furthermore, our model revealed a significant link between high school study and high school grade point average for all students. But, this link was statistically stronger for remedial students indicating, once again, the need for strong study skills for all students. We therefore conclude that the inculcating of strong study habits is extremely important for students enrolled in all levels of instruction, but may be especially important for remedial level students.

Our model contained two significant paths that appear to be counter-intuitive and contrary to our hypotheses. First, we found a significant negative path between parent education and high school study habits among non-remedial students. In other words, for students able to initially enroll in college level mathematics, good study habits were associated with lower parent education. Equally troubling was a significant and negative path from income to the high school study habits of remedial students. We interpret these two findings to indicate that highly educated parents may be working at high level jobs that require vast amounts of time that leave scant time for parent-child interaction. This situation may not be conducive to instilling appropriate study skills and hence has a negative effect on some students. Or, it may be that parents with tight time constraints are not able to appropriately supervise the study habits of their children. We would therefore advocate future studies to investigate the relationship between income, education and parenting to see if a curvilinear relationship is actually a more appropriate explanation for this phenomena.

Final Words

Richard W. Riley, the U.S. Secretary of Education, recently provided a statement about the math and science achievement of U.S. Students (Pursuing excellence, 1996). In short Secretary Riley stressed the need for improvements that go beyond increasing class time and homework or decreasing the role of television. Rather, Secretary Riley espoused the need for changes in teacher preparation and the rigor and content in curriculum at all levels of education. Our findings concur with Secretary Riley's statement and support the importance of taking steps to prepare U.S. students to be successful in a knowledge based economy.

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Table 1. Items and scales used in the model.

Construct	Items	Alpha
Parents' Education	Level of mother's education Level of father's Education	.7646
Gender	0=Male 1=Female	
Ethnicity	0=Non-minority 1=Minority	
Family Income	1=Less than $6000 2=$6000 to $9999 3=$10000 to $14999 4=$15000 to $19999 5=$20000 to $24999 6=$25000 to $29999 7=$30000 to $34999 8=$35000 to $39999 9=$40000 to $49999 10=$50000 to $59999 11=$60000 to $74999 12=$75000 to $99999 13=$100000 to $149999 14=$150000 or more	
Racial composition of high school and neighborhood	Racial composition of high school Racial composition of neighborhood	.8170
Encouragement to go to college	Encouragement from family Encouragement from teachers and counselors Encouragement from friends	.6152
High school study habits	Number of weekly hours spent studying while in high school	Single item
High school GPA	Self reported high school grade point average 6=A 5=A-, B+ 4=B 3=B-, C+ 2=C, C- 1=D+ or lower	Single item

Table 1. (cont'd) Items and scales used in the model.

Perceptions of teaching	1. Material is well organized 2. Instructors are well prepared 3. Class time is used effectively 4. Course goals are clearly explained 5. Instructors have good subject command 6. Instructors give good explanations 7. Instructors use of examples and illustrations 8. Instructors effectively review and summarize the material 9. Instructors interpret abstract ideas and theories clearly 10. Instructors lead stimulating class discussions 11. Courses are challenging 12. Instructors are available for consultation 13. Examinations reflect material emphasized in the course 14. Instructors answer my questions in ways that help me understand	.9203
Math enrollment[2]	1=Pre-algebra or arithmetic 2=Algebra or geometry 3=Calculus or statistics 4=Matrix algebra	
College study habits	Learning in student groups Participation in study groups Frequent study with a friend	.7989
Dependent Variable: Mathematics Achievement Test	Raw score on CAAP Mathematics Test	

[2] Remedial mathematics included (1) pre-algebra or arithmetic, and (2) algebra or geometry. Non-remedial math included (3) calculus or statistics, and (4) matrix algebra.

Table 2a. Non-Parametric Descriptive Analysis by Remedial/Non-Remedial Math Enrollment Status.

	Gender	Minority
Chi Square	13.602	52.674
df	1	1
Asymp. Sig.	<.0001	<.0001

Table 2b. Descriptive Analysis by Remedial /Non-Remedial Math Enrollment Status

Variable	Non-Remedial		Remedial		F statistic	Sig.	Higher Group
	Mean	S.D.	Mean	S.D.			
Parent Education	5.182	2.050	4.297	2.039	86.844	<.0001	Non-Remedial
Family Income	8.47	3.35	6.93	3.48	91.376	<.0001	Non-Remedial
Encouragement to go to college	3.603	0.523	3.442	0.590	39.202	<.0001	Non-Remedial
Racial composition of high school & Neighborhood	3.711	1.173	3.299	1.272	53.179	<.0001	Non-Remedial
High school study habits	3.12	.81	3.02	.78	6.673	<.01	Non-Remedial
High school GPA	5.00	1.06	4.05	1.22	332.6	<.0001	Non-Remedial
College Study Habits	2.411	.6373	2.349	.6459	4.395	<.05	Non-Remedial
Perceptions of teaching	3.083	0.477	3.013	0.488	9.964	<.001	Non-Remedial
Math CAAP test score	22.08	6.69	13.53	5.04	969.95	<.0001	Non-Remedial

Table 3. Coefficients of Determination for Path Models for Remedial and Non-Remedial Students

		Non-Remedial		Remedial		Significant Group
Dependent Variable	**Independent Variables**	**R^2**	**Path Coefficient (β)**	**R^2**	**Path Coefficient (β)**	**t-test of the b (unstandardized) regression weight α = .05**
Math Achievement Score	Perceptions of teaching	.08398	.0048	.07868	-.0011	--
	College study habits		-.0288		-.0023	--
	Math enrollment		-.0159		.1100*	Remedial only
	Racial composition		.2858*		.2586*	t=6.708* Non-remedial
Perceptions of Teaching	High school GPA	.01693	.0484	02547	.0356	--
	Racial composition		.0546		.0482	--
	Gender		.0988*		.1436*	$t=1.122^{ns}$
College Study Habits	High school study habits	.02821	.1000*	.08709	.2189*	t=2.594* Remedial
	Encouragement		.0541		.1289*	Remedial only
	Gender		.0869*		.0608	Non-remedial only
Math Enrollment	High school GPA	.00655	.0654	.01127	.0829*	Remedial only
	High school study		-.0398		.0251	--
	Racial composition		-.0088		.0088	--
	Ethnicity		-.00607		.0345	--
	Gender		.0288		-.0736*	Remedial only
High school GPA	High school study	.05088	.2123*	.09802	.3024*	t=2.932* Remedial
	SES		.0874*		.1107*	$t=0.7486^{ns}$
High school study habits	Racial composition	.19892	.0070	.09116	.0326	--
	Encouragement		.1002*		.1596*	t=2.751* Non-remedial
	SES		.1091*		-.0862*	t=3.824* Non-remedial
	Ethnicity		.0768		.0573	--
	Gender		.2672*		.2114*	$t=1.155^{ns}$
	Parents' education		-.3593*		.0047	Non-remedial only

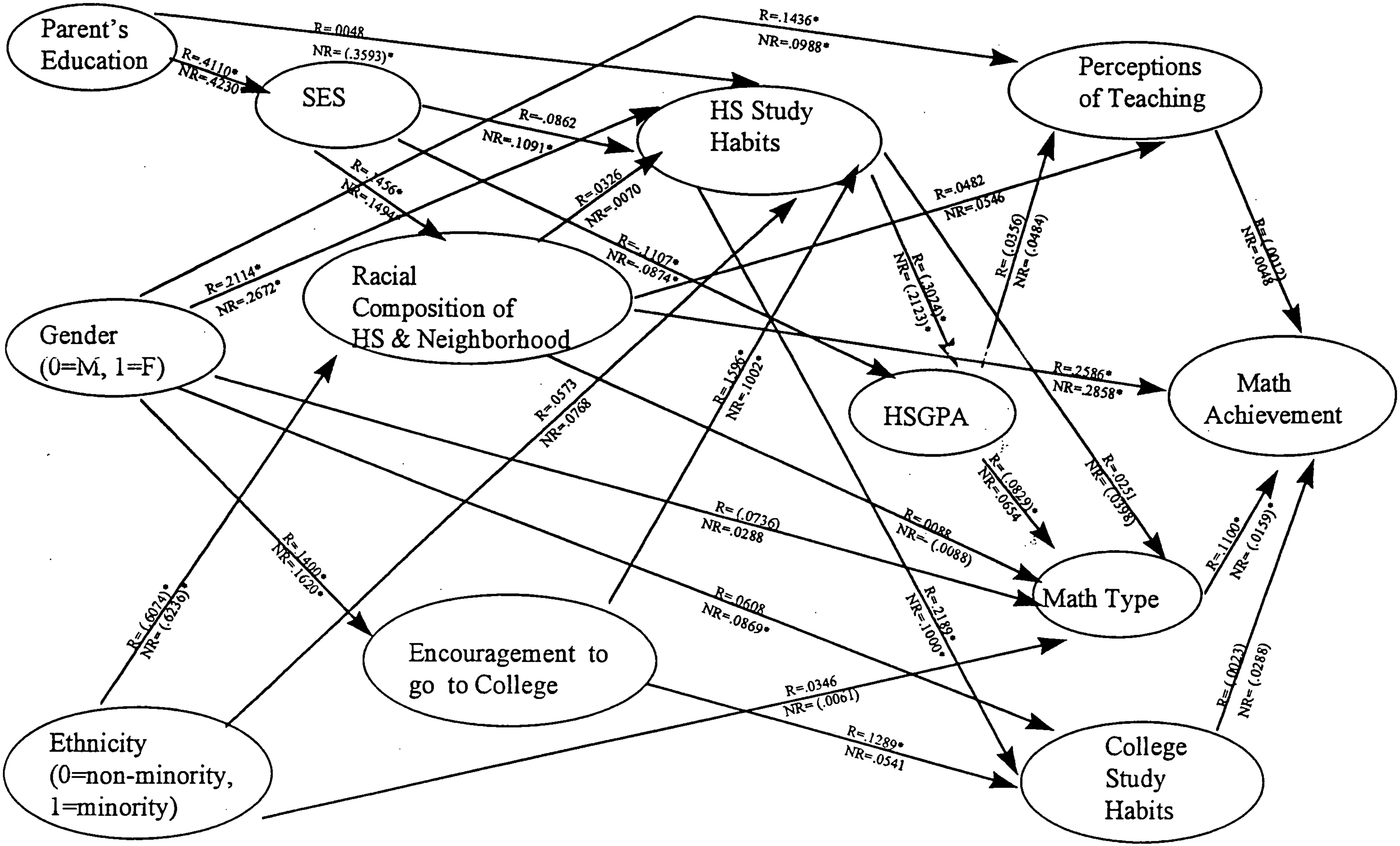
Table 3 Coefficients of Determination for Path Models for Remedial and Non-Remedial Students (Continued)

		Non-Remedial		Remedial		Significant Group
Dependent Variable	**Independent Variables**	**R^2**	**Path Coefficient (β)**	**R^2**	**Path Coefficient (β)**	**t-test of the b (unstandardized) regression weight $\alpha = .05$**
Racial Composition	SES Ethnicity	.46783	.1494* -.6236*	.44675	.1456* -.6074*	t=0.0807 ^{ns} t=0.256 ^{ns}
Encouragement	Gender	.02624	.1620*	01960	.1400*	t=0.0815 ^{ns}
Income	Parents' education	.17893	.4230*	.16892	.4110*	t=0.0951 ^{ns}

Table 4. Summary of Effects to Math Achievement Test

	Non-Remedial			Remedial		
Independent Variable	**Direct**	**Indirect**	**Total**	**Direct**	**Indirect**	**Total**
Perceptions of teaching	.0048		.0048	-.0012		-.0012
College study habits	-.0288		-.0288	-.0023		-.0023
Math enrollment	-.0159		-.0159	.1100*		.1100*
High school GPA		-.0013	-.0013		-.0091	-.0091
High school study habits		-.0020	-.0020		.0050	.0050
Racial composition	.2858*	.0004	.2861*	.2586*	.0011	.2597*
Encouragement		-.0018	-.0018		.0005	.0005
SES		.0427*	.0427*		.0384	.0384
Ethnicity		-.1785*	-.1785*		-.1536	-.1536
Gender		-.0033	-.0033		-.0073	-.0073
Parents' education		.0188*	.0188*		.0158	.0158

Figure 1. Path Model for Math Achievement for Both Remedial and Non-Remedial Students



R = Remedial ; NR = Non-Remedial
Note: Negative Values are Bracketed

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