Mathematics Attitudes and Achievement of U.S. High School Sophomores Based on Race

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Abstract

What are high school students thinking? The purpose of this study was to examine the degree that psychosocial attitudes affect academic achievement in mathematics for students of different races during secondary schooling. Based on a quantitative methodology, data was gathered from a nationally distributed survey involving over 16,000 student participants under the auspices of the National Center for Education Statistics (NCES). Transcript information was incorporated into the analysis, so student math attitudes and student racial profiles could be correlated to courses taken and grades. Significant differences were found when comparing Latina/o to non- Latina/o students with regard to student self-evaluations of mathematics affinity, appreciation and capacity. Subsequent analyses revealed that Latina/os are significantly less prepared than their non-Latina/o peers in terms of the highest level of math course completed. The implications of this study endorse revisions to student mathematics course placement procedures, as well as mentorship and other promotional programs for underrepresented minority students. The results of this study inform policy makers, administrators, teachers, and other educational advocates whose interests lie in decreasing inequities that exist among students from a diverse range of racial backgrounds.

Keywords: *mathematics, equity, achievement, race, policy, curriculum, quantitative*

Introduction/Purpose

It has been said that innovation is the lifeblood of 21st century learning. In Vivian Stewart's (2012) book, *A World-Class Education*, she states,

> the old basics are still important, but the new basics will be required, including a deeper understanding of academic content, the ability to apply knowledge to new problems, and a set of strategies to enable students to "learn how to learn," be creative, and take control of their own learning. (p. 141)

In the United States, there are numerous obstacles that either encourage or inhibit students in their preparations for a future where innovative skills are essential for success. It is the premise of this study that individual attitudes about learning affect academic performance for these students.

The purpose of this study was to determine the relationship between the epistemological development and academic performance in mathematics among secondary-level, public school Latina/o students. This was a quantitative study which defined relationships between these factors, and identified potential reasons for any degree of correlation. The research questions for this study were 1) to what degree are psychosocial variables related to academic achievement in mathematics among Latina/o high school sophomores and their non-Latina/o peers?; and, 2) how well do psychosocial attitudes related to mathematics and reported race predict academic achievement for Latina/o and non-Latina/o high school sophomores?

With the current emphasis on secondary-level students to obtain the necessary skills to prepare them for college or career opportunities in the 21st century, researchers and educational practitioners alike have engaged in a continuing effort to better understand barriers to academic success for specific subgroups of students, including secondary-level Latina/os. For the purposes of this study, the term Latina/o refers to individuals who not only identify themselves as having Latin American ancestry, but includes others who identify themselves, informally or formally, as Hispanic. This is important to note, especially considering the use of both terms, many times interchangeably, in the literature used to inform this study.

Additionally, the data used in this study to generate results prompted student self-reports of their own race, based on personal perceptions of racial designations. Recent data reveal that Latina/os as a whole constituted 14 percent of the U.S. domestic population in 2005 and projections estimate that by 2050, citizens of Latina/o origin will comprise 28 percent of the overall U.S. population (Cohn and Passel, 2013). Moreover, by the mid-21st century, school-age Latina/os who are under eighteen years old will comprise seven percent of the overall population, or approximately twenty-nine million youths, which is more than the population of all residents of the state of Texas as of July, 2014 (United States Census Bureau, 2015).

Theoretical Framework

While traditional choices of analytical/theoretical frameworks for studies related to race are, for example, critical race theory and/or social cultural theory, the principal investigator for this study opted to use an epistemological lens to focus on self-efficacy as it relates to academic performance for students of various races. This choice allowed for a broader interpretation of the psychological processes involved, and aligned more precisely with data investigated that revealed how students interpreted their own abilities to access, learn and achieve in the area of mathematics. Epistemology can be broadly defined as "the branch of philosophy which aims at understanding such concepts as memory, certainty, doubt, justification, evidence and knowledge" (Cooper, 1999, p.1). Historically used by qualitative researchers to inspect aspects of self-learning and self-authorship, more recent studies by established researchers substantiate use of quantitative methodologies as a valid measure of epistemological phenomena.

In an article entitled "Preliminary Evidence of the Reliability and Validity of a Quantitative Measure of Self-Authorship" (2010), authors Baxter-Magolda, Creamer and Yue state that a "quantitative measure of (epistemological phenomena) will add to the impetus for practitioners to create educational interventions targeted at promoting self-authored ways of reasoning" (p. 551). More practically, the robust quantitative data used in this study was obtained as a result of students expressing their feelings about self-efficacy in relation to mathematics concepts and practices.

While important, epistemological investigations that focus on the degree to which student attainment of knowledge of mathematics is socially constructed and/or created on "blank slates" are not offered here (due to space limitations) but relate well to this particular area of study.

Methods

This study utilized a quantitative methodology to derive correlations between variables, and described the degrees to which factors are related. The study used data gathered in a national, longitudinal survey gathered under the auspices of the National Center for Education Statistics (NCES), more specifically the Education Longitudinal Study of 2002 (ELS: 2002). The initial phase of the survey, involved a stratified national probability sample of 16,200 students from 1,015 public and private high schools. In 2005, when the student transcript data was released to the NCES by the participants' schools, specific security measures were taken to ensure the confidentiality of this data.

Primarily, variables used in the study related to the degree that the students surveyed felt they could learn mathematics, based on personal perceptions of capacity and personal efficacy, both in and out of the classroom environment. For example, in terms of capacity, students were asked to gauge whether "most people can learn to be good at math" or whether people "have to be born with ability to be good at math." In terms of efficacy, students were asked, among other questions, whether they "can do excellent job on math tests," "can understand difficult math texts," "can understand difficult (concepts presented in) math class," and "can do excellent job on math assignments." To further determine the degree that high school sophomores achieve academically in mathematics, quantitative dependent variables such as course grades and highest course levels completed in this subject area were also included in this investigation.

Other independent variables measured by this study's methodological instrument included student reported race, parents' highest level of education, family socioeconomic status (SES), reported attitudes about mathematics, level of participation in extracurricular activities, number of hours per week students were watching television and computer/video entertainment, and the number of hours per week students surveyed worked outside of the home. Contributive findings for this study were obtained through the use of a number of descriptive and inferential statistical methods including t-tests, cross-tabulations (e.g. Chi-square), and one way analyses of variance (i.e. ANOVA) results of which are provided in the accompanying tables and figures.

Results

As a whole, the statistical analyses revealed significant differences by participants as they related their feelings about personal mathematics attitudes and learning capacities, based on reported race. With regard to statistical analyses that measured student epistemological/self-efficacy feelings, it is clear that the Latina/o students in the study feel very differently than non-Latina/os in terms of their enjoyment of mathematics and their capacity to learn mathematics. Table 1 (next page) shows that Latina/os were different from non-Latina/os on variables related to attitudes about math, responding to questions that assess the participant's feelings that a) most people can learn to be good at math, b) a person has to be born with ability to be good at math, c) math is fun and d) mathematics is important.

Table 1: ***Comparison of Survey Responses of Latina/o and non-Latina/o Students Regarding Attitudes about Mathematics and Personal Mathematics Efficacy (n = 1,540 Latina/o participants and n = 10,130 non-Latina/o participants)***

Variable	*M*	*SD*	*t*	*df*	*p*	*d*
Most people can learn to be good at math			-2.787	11670	.005	-0.1
Latina/os	1.76	1.521				
non-Latina/os	1.88	1.539				
Have to be born with ability to be good at math			1.055	11670	.303	.04
Latina/o s	2.61	1.837				
non-Latina/os	2.55	1.780				
Thinks math is fun			-4.472	11670	.000	-0.1
Latina/os	2.70	.824				
non-Latina/os	2.80	.842				
Mathematics is important			-3.945	11670	.000	-0.1
Latina/os	2.29	1.512				

Additionally, Table 2 (next page) shows that Latina/os responded differently than non-Latina/os on variables related to student math efficacy, responding to questions that assess the participant's feelings that a) he/she can do excellent job on math tests, b) he/she can understand difficult math texts, c) he/she can understand difficult math classes and d) he/she can do excellent job on math assignments.

Table 2: ***Comparison of Survey Responses of Latina/o and non-Latina/o Students Regarding Attitudes about Mathematics and Personal Mathematics Self-Efficacy (n = 1,540 Latina/o participants and n = 10,134 non-Latina/o participants)***

Variable	*M*	*SD*	*t*	*df*	*p*	*d*
Can do excellent job on math tests			-3.606	11670	.001	-0.1
Latina/os	1.96	2.479				
non-Latina/os	2.18	2.250				
Can understand difficult math texts			-3.392	11670	.001	-0.1
Latina/os	1.74	2.592				
non-Latina/os	1.96	2.322				
Can understand difficult math class			-2.709	11670	.007	-0.1
Latina/os	1.48	3.290				
non-Latina/os	1.71	3.026				
Can do excellent job on math assignments			-2.950	11670	.003	-0.2
Latina/os	1.37	3.661				
non-Latina/os	1.65	3.375				

These attitudes may result in a "self-fulfilling prophecy" where Latina/o student attitudes lower motivations to perform well in the subject area and, as a result, these students are subsequently placed in lower level math classes, relative to non-Latina/o students.

With regard to the highest math course taken one semester or more, it was determined that students from different races were differentially prepared in mathematics as a result of the highest mathematics class completed for a semester or more throughout their high school experience. Table 3 shows the Pearson Chi-square results and indicates that a student's observed highest math course is significantly different than expected, based on their reported race. Latina/os and African Americans are much more likely than expected under the null hypothesis to complete at least one semester of a class which is lower level than Whites or Asians. For example, of the nearly 13,000 students surveyed, four thousand and seventeen (or 50.4%) of Whites completed a trigonometry,

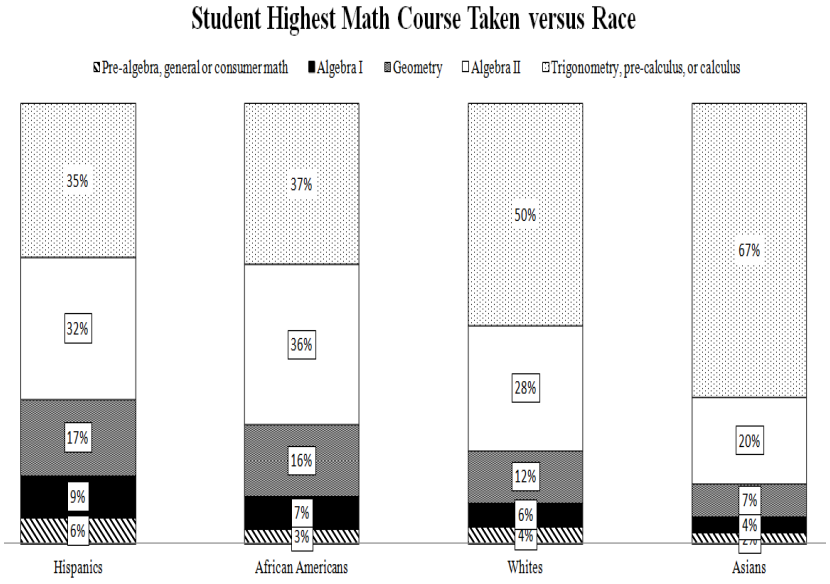
pre-calculus, or calculus course in high school, while only six hundred and seventy-seven (or 34.9%) of Latina/os reached that level.

Table 3: ***Chi-square Analysis of Prevalence of Highest Mathematics Course Completed among Asians, African Americans, Latina/os, and Whites***

		Reported Race					
Variable	*n*	Asians	African Americans	Latina/os	Whites	χ^2	*p*
Highest Course Completed						463.43	.000
Pre-algebra, general or consumer math	510	30	60	120	310		
Algebra I	800	50	130	180	440		
Geometry	1670	90	290	340	940		
Algebra II	3800	250	650	630	2270		
Trigonometry, pre-calculus, or calculus	6190	840	660	680	4020		
Totals	12960	1260	1790	1940	7980		

Figure 4 displays the data provided in Table 3 in a graphical representation, illuminating the differences between highest math courses taken for at least one semester for students in the survey of differing reported races.

Figure 4: ***Prevalence of Highest Mathematics Course Completed among Asians African Americans, Latina/o s, and Whites (for students who completed at least a semester)***



This result, and the knowledge that 84 percent of Latina/o students and 72 percent of Asian students in this study were not "on track" (i.e. they were not enrolled in geometry in their sophomore year), further illuminates discrepancies in course taking by race. It was not within the scope of this study to determine the degree that instructional practices and classroom learning behaviors in lower level mathematics classes are affected by inhibiting Latina/o student attitudes. However, previous studies have made connections in other subjects (e.g. science), where students from diverse backgrounds receive lower quality instruction with less access to inquiry based practices, than their non-URM peers (Lee & Buxton, 2011).

A most intriguing result was obtained from an analysis of variance (ANOVA) test, as seen in Tables 5 and 6, which revealed that transcript grades for Latina/o and African American study participants who had completed geometry in their sophomore year were higher than White and Asian study participants (lower mean, *M*, correlating to a higher transcript grade per convention outlined in Table 6). At first look, this result is counterintuitive until you take into account that more Asian and White study participants are enrolled in higher level classes (than geometry) during their sophomore year and most Latina/o and African American study participants enrolled in lower level classes during their sophomore year.

Table 5: ***One-Way Analysis of Variance (ANOVA) Summary Table Comparing Transcript Grades for Sophomore Participants Taking Geometry in 2001-2002 on Reported Race***

					95% Confidence Interval for Mean			
	n	*M*	*SD*	*Std. Error*	Lower Bound	Upper Bound	Min	Max
Asian	350	6.6171	3.12296	.16813	6.2864	6.9479	1.00	13.00
Black	800	6.5442	3.06275	.10828	6.3316	6.7567	1.00	13.00
Latina/o	310	6.3181	3.05879	.17457	5.9746	6.6617	1.00	13.00
White	3140	6.9054	3.21342	.05735	6.7930	7.0179	1.00	13.00
Total	4590	6.7816	3.17551	.04686	6.6897	6.8734	1.00	13.00

Table 6: Student Transcript Grades Correlations to F1CGRADE Variable Designation Values for Sophomore Participants Completing Geometry in 2001-2002 (n = 4,590)

F1CGRADE Value	*Student Transcript Grade*
1	A+
2	A
3	A-
4	B+
5	B
6	B-
7	C+
8	C
9	C-
10	D+
11	D
12	D-
13	F

As a result, Latina/o and African American sophomores in the study who were enrolled in geometry classes (and were considered "on track") may be the highest achieving students within the study's participants for their reported races, and Asian and White sophomores in the study who were enrolled in geometry classes as sophomores included some of the lowest achieving students within the study's participants for their reported races.

Analysis

The results of this study give rise to a number of possible implications in educational theory, practice, and policy. There is evidence that differences in student self-efficacy for students of different races, borne out of a sense of capacity for mathematics learning/achievement, correlate to affinity/enjoyment in the subject for these students. Additionally, the percentage of students that are considered to be "on track" (in this study, taking geometry as a sophomore) vary widely, with disparate differences along race lines.

Latina/o students at the secondary level were differentially less prepared in mathematics than their non-Latina/o peers in terms of the highest level of math course taken in high school. In contrast, when students from the same survey were compared at the same course level (geometry) during the same school year (10th grade), Latina/os obtained significantly higher course grades than their non-Latina/o peers. It should be noted that, due to time limitations, determining the level of academic achievement in more advanced mathematics classes by these Latina/o participants who were enrolled in Geometry as sophomores was not obtained. It could not be determined, therefore, whether student perception of self-efficacy compared favorably with teacher/administrator assumptions about student capacity to perform in higher levels of mathematics.

Curricular Considerations

As of the writing of this dissertation, there are a number of current curricular and instructional changes related to the adoption of the Common Core State Standards for Mathematics (CCSSM) that may alter the contextual landscape for URMs, including Latina/o students. As the majority of the States have adopted these standards, they have also endorsed the use of one or more corresponding instructional strategies that align to these standards. Included in these strategies is an emphasis on open conversational discourse during instructional time in order to heighten critical thinking in the classrooms. Including more student discourse in mathematics classrooms will increase opportunities for Latina/o students with limited English proficiency to participate in relevant classroom discussions, thereby improving their understanding of the material presented. Implementing additional, research-based pedagogical practices with the adoption of the CCSSM has significant potential to increase the scholarship of Latina/o ELLs who "lack the necessary English language skills to comprehend instruction" (Gasbarra & Johnson, 2008, p.2).

Additionally, structural changes are also being recommended to the established curriculum as part of the CCSSM implementation, including the removal of the traditional, hierarchical course sequence (e.g. Algebra 1, Geometry, Algebra 2, etc.) in favor of a series of courses, each of which include a variety of integrated mathematical concepts for students to explore at ever increasing levels (e.g. Integrated Mathematics I, Integrated Mathematics II, Integrated Mathematics III, etc.). The results of this study reveal that Latina/o students in the United States, relative to their non-Latina/o peers, are enrolling in a limited set of mathematics courses during their high school years.

Modifying the curricular landscape as part of the CCSSM adoption provides opportunities for Latina/o and other URM students access to a broader array of mathematical concepts, which may have been beyond their reach previously. These structural changes to the mathematics curriculum has great potential to place ethnic minorities, including English Language Learners (ELLs) and lower socioeconomic (SES) students, in more equitable educational settings (Crisp & Nora, 2012; Nasir et al., 2012).

Conclusions

As a result of both descriptive and inferential statistical analyses, a number of key findings show that, in 2002, there were significant differences in comparing Latina/o to non-Latina/o students with regard to student self-evaluations of mathematics affinity, appreciation and capacity. In terms of implications to practice and policy, educators would do well to recognize the significance of student math attitudes, and how these attitudes might affect academic performance and course placement for students of differing races. Secondary administrators who supervise students who are differentially prepared in mathematics based on race are encouraged to create policies that can "stem the tide." allowing for more equity across race lines.

One practical measure that could assist with this effort would be to create more open course pathways so students could more easily change from their assigned course to another. In the preliminary high school years, this effort may be aided due to differing cognitive emphases of Algebra (computational) and Geometry (spatial). Also, the support of summer school classes for students to advance to higher levels of mathematics will provide the opportunity for URM students to "move tracks," and ultimately allow them access to more advanced levels of instruction. A major limitation in this study is determining the relative degree that administrators, students and parents are involved in course selection of high school mathematics classes across the United States.

Limited anecdotal evidence by the principal investigator of this study, a secondary mathematics teacher with eight years of experience in both public and private settings during the timeframe of the survey used, supports the idea that high school math courses were strictly assigned based on established programmatic pathways (defined by academic performance standards met), monitored by school counselors. Under these conditions, there would be little to no opportunity for administrator, student and/or influence on course placements.

However, school administrators who recognize the self-efficacy aspects related to race and mathematics achievement are encouraged to connect local Latina/o role-models who have achieved success in STEM fields with their students, providing encouragement for these students. Finally, placing instruction at the center of intervention, assigning the more effective math teachers at each site to classes with a higher percentage of Latina/o students, as well as providing effective outside-of-class tutoring programs for these students, has the potential to "level the playing field" for these students. Results of this study show that Latina/o students need both an increase in internal motivation and positive, productive external learning environments to increase the potential for success in mathematics at the secondary level.

There are a number of contextual and methodological implications which bound the generalizability of these results, as well as procedural limitations and delimitations. In recognizing the bounds of this study, both in scope and process, future researchers are encouraged to further explore the relationship between mathematical ways of knowing, race and academic achievement. The results of this study inform all educators whose interests lie in decreasing inequities that exist

among students from a diverse range of racial backgrounds in the United States, as well as increasing Latina/o student attainment of 21st century skills in mathematics.

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