Do Individual Learner Variables Contribute to Differences in Mathematics Performance

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The present study (*n* = 761, 58.1% female) examined whether or not individual learner variables (gender, ethnicity, SES) contribute to differences in mathematics performance as measured by test score and mathematics grade for fifth and sixth grade mathematics students in Alabama. Multiple regression analysis revealed that gender and SES show negatively significant, but small, relationships with mathematics performance as measured by test score and mathematics grade. Students receiving free-reduced lunch (SES) scored lower on the mathematics test than those students not receiving free-reduced lunch. Gender (p<.001) and free-reduced lunch (p<.001) significantly contributed to differences in mathematics performance as measured by mathematics grade with female students and those students receiving free-reduced lunch having lower grades in their current mathematics class. Ethnicity was not significant in predicting mathematics performance as measured by test score or mathematics grade.

Introduction

Differences in mathematics performance have received serious attention in the field of mathematics education for decades in the United States. After strong evidence for a male advantage in mathematics, studies consistently found that males outperformed females (Ding, Song, & Richardson, 2006) and that minority students lag behind on standardized test scores (Everson & Millsap, 2004).

Allexsaht-Snider and Hart (2001) have identified equity as all students learning and using mathematics regardless of their race, ethnicity, class, gender, or language proficiency. Hence, many factors are linked to equity in student access to mathematics education such as mathematics achievement, course enrollment, interest, motivation, and valuing of mathematics (Allexsaht-Snider & Hart, 2001). It is also noted that beliefs about intelligence, as well as beliefs about how students learn, the learning potential of students of color and of poor and female students, are all connected with other important aspects for achieving equity in mathematics education (Allexsaht-Snider & Hart, 2001).

Ai (2002) examined gender differences in growth in mathematics achievement in relation to attitude toward mathematics, self-esteem, parents' academic encouragement, mathematics teachers' expectations, and peer influence. This study was based upon data from the Longitudinal Study of American Youth (LSAY) and represented students from grades seven to grade ten.

The results indicated a small, but significant gender gap in mathematics achievement at grade seven, in favor of those females who started out low in mathematics. Females' mathematics attitude effect was found to be smaller than males' in both low and high groups. Further, the results indicated that females' attitude toward mathematics on math scores was related to mathematics teacher encouragement and parent encouragement, while males' attitude toward mathematics was independent of teachers and parent influences (Ai, 2002).

Singham (2003) has stressed that the achievement gap between black and white students is "one of the most infuriating problems afflicting education" (p. 586). There are many myths that can be linked to the causes of the achievement gap that is seen between African American students and white students. These causes include biased standardized tests, tests that fail to match the learning styles of black students, less money being spent to educate black students, differences in socioeconomic status, lack of motivation, peer pressure, lack of family support for education, teacher biases, as well as other possibilities. While all of these causes contain some truth, no one cause alone can be used to explain the achievement gap.

By looking at the data provided by NAEP (National Assessment of Educational Progress) for mathematics, it can be seen that for students in 12th grade, the average white score was 308 and the average black score was 274 (Singham, 2003). Singham (2003) suggests that the focus should be placed on the difference between where all students are now and where it is believed that they should be. The NAEP data allows such comparisons due to the specificity of benchmark levels. A basic level of achievement in mathematics (partial mastery of knowledge and skills that are fundamental for proficient work) for students in grade 12 requires a minimum score of 288, while a score of 336 is needed for a proficient level (representing solid academic performance and competency over challenging subject matter). An advanced level of achievement in mathematics (representing superior performance) requires a minimum score of 367. While NAEP feels that all students should reach the proficient level (score of 336), the average scores for both black students and white students are well below the proficient level.

Another confounding factor related to the achievement gap between blacks and whites is the impact of teacher expectations, which is three times greater for blacks than for whites and "also larger for girls and for children from low-income families" (Singham, 2003, p. 589). However, student performance is only affected minimally by the ethnicity of the teacher, with black females (81%) and black males (62%) wanting to please their teacher more than they want to please a parent. For white females and white males, 28% and 32% respectively want to please their teacher more than they want to please a parent. Unfortunately, eliminating the achievement gap is focused mainly on what should be done with minority students, making it look as if it is only a minority problem. Therefore, the focus needs to be shifted so that the achievement gap "is a symptom of more widespread educational problems" (Singham, 2003, p. 591).

Statement of Purpose

The purpose of this study was to determine whether or not individual learner variables contribute to differences in mathematics performance. Information from this study will help increase teacher awareness of the idea that individual learner variables such as gender, ethnicity, and socio-economic status (SES) do in fact contribute to differences in mathematics performance.

Methods

Participants

The participants in this study were fifth and sixth grade students (N=761) taking a mathematics course. There were 301 fifth graders and 460 sixth graders. Of the participants, 58.1% were female; 42.6% were African American, 49.7% were White, 1.3% were Hispanic American, 2.1%

were Native American, 1.7% were biracial/multi-ethnic, and 1.6% indicated something other than listed. In addition, 60.0% reported receiving free or reduced lunch, and 95% indicated that English was the primary language spoken at home.

Academic Performance

Academic performance was measured by collecting data on students' performance in their current mathematics classroom. In addition, each participant completed a 20 problem, teacher-made mathematics test which was constructed in alignment with the Alabama Course of Study and the Georgia Criterion Referenced Competency Test. These test items were selected based on the assumption that the Alabama Course of Study, in agreement with the Principles and Standards for School Mathematics (NCTM, 2000), suggests that by the end of the fifth grade students should have mastered these types of mathematics items. The items that were included on the test (See Appendix A) were selected because they cover material from the content standards that assess number sense, number systems, and number theory; geometry, spatial sense, and measurement; probability, statistics, and discrete mathematics; and patterns, functions, and algebra. In addition, these items were included because they address mathematical processes (i.e., problem solving, connections, reasoning) and require students to draw upon these processes to solve the test items. Scores for the test were computed by assigning a one for each correct answer and a zero for each incorrect answer, with a total possible score of 20. Cronbach's alpha was used to estimate the internal reliability of the Mathematics Test ($\alpha = .70$).

Procedure

The target population consisted of 1,864 fifth- and sixth-grade students currently in elementary and middle schools. The assessable population comprised 60 intact classes with 30 made up of fifth grade students and 30 made up of sixth grade students. Classes were selected on the basis of the teachers' willingness to yield class time to the researcher. A list of schools (city and county) was obtained from the Alabama State Department of Education. Those schools located within a 60-mile radius of the participating University were selected by using systematic random sampling. This resulted in a total of 14 schools to be contacted for participation in this study.

Each school administrator received packets that included a cover letter, consent forms, surveys, and incentives for participation (e.g., University pens, notepads, College of Education bookmarks, etc.). Seven schools agreed to participate in this study with two schools requesting that the surveys not be administered until a later date and, therefore, are not included in this study. After initial review of the packets, the teachers and students were informed about the details of this study and consent forms were given out to the participants to have signed by a parent or legal guardian. The participants were given parental consent forms to take home and return signed. Those who returned a signed consent form were allowed to participate. Each participant was read the purpose of the study and then completed the packet of instruments during one 90-minute class period or two 50-minute class periods during the spring Semester, 2004.

Two multiple regression correlations were performed in order to assess the relationship between the independent variables (gender, ethnicity, and SES) and the dependent variable (mathematics performance) as measure by test score and mathematics grade.

Results

The research question was whether or not individual learner variables (i.e., gender, ethnicity, SES) contribute to differences in mathematics performance or can help predict mathematics performance. Regression results indicate that the overall model significantly predicts test score, $R^2=.030$, $R^2_{adj}=.026$, $F(3,723)=7.409$, $p<.001$. This model accounts for 3% of variance in test score. A summary of the regression model and coefficients is presented in Table 1 and indicates that only one (free-reduced lunch) of the three variables significantly contributed to the model.

For mathematics grade, regression results indicate significance for the overall model, $R^2=.054$, $R^2_{adj}=.050$, $F(3,663)=12.702$, $p<.001$. This model accounts for 5.4% of variance in mathematics grade. A summary of the regression model and coefficients is presented in Table 2 and indicates that two (gender and free-reduced lunch) of the three variables significantly contributed to the model.

Discussion

The evidence from this study continues to echo previous research (Everson & Millsap, 2004; Lee, 2000) in that students SES, race, and ethnicity are meaningful predictors of student achievement, outside of the individual differences that students carry with them to the schools. Lee (2000) reports that student's learning is strongly influenced by the contexts in which it occurs.

The individual learner variable, SES as measured by free-reduced lunch, showed some significant relationship to mathematics perfor-

Table 1

Model Summary & Coefficients for Model Variables for Overall Sample

	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	df1	df2	p
FULL MODEL	.173	.030	.026	.030	7.409	3	723	<.001
RESTRICTED MODEL	.171	.029	.028	.000	.226	1	724	.635

	B	ß	t	p	Bivariate r	Partial r
FULL MODEL						
GENDER	.119	.017	.468	.640	.022	.017
ETHNICITY	.048	.016	.443	.658	.030	.016
FRLUNCH	-1.192	-.169	-4.606	<.001**	-.171	-.169
RESTRICTED MODEL						
FRLUNCH	-1.204	-.171	-4.675	<.001***	-.171	-.171

*p<.05, **p<.01, ***p<.001
(DV=Test Score)

Table 2

Model Summary & Coefficients for Model Variables for Overall Sample

	R	R^2	R^2_{adj}	ΔR^2	F_{chg}	df1	df2	p
FULL MODEL	.233	.054	.050	.054	12.702	3	663	<.001
RESTRICTED MODEL	.233	.054	.051	.000	.111	1	663	.739

	B	ß	t	p	Bivariate r	Partial r
FULL MODEL						
GENDER	-4.858	-.168	-4.435	<.001***	-.165	-.170
ETHNICITY	-.1590	-.013	-.334	.739	-.002	-.013
FRLUNCH	-4.857	-.165	-4.365	<.001***	-.161	-.167
RESTRICTED MODEL						
GENDER	-4.864	-.168	-4.445	<.001**	-.165	-.170
FRLUNCH	-4.827	-.164	-4.355	<.001***	-.161	-.167

*p<.05, **p<.01, ***p<.001
(DV=Mathematics Grade)

mance as measured by test score. Those students receiving free-reduced lunch scored lower on the mathematics test than those students who do not receive free-reduced lunch. In fact, SES seems to explain some achievement differences, while students who received free-lunch at school scored lower than did students who were not eligible for free-lunch.

Further results indicate that gender and free-reduced lunch significantly contributed to differences in mathematics performance as measured by mathematics grade. Although gender somewhat significantly contributed to mathematics grade, research indicates that the gender gap in mathematics is closing. A small, but significant gender gap in mathematics achievement at grade seven was found in favor of females (Ai, 2002).

Tate (1997) has reported that even though males tend to outperform females on standardized measures of mathematics achievement the differences were generally small and not significant. While gender differences exist and are still being observed, they are generally small regarding the amount of variance explained (Wigfield & Eccles, 2001).

On the other hand, research supporting SES indicates that SES (free-reduced lunch) contributes to differences in mathematics performance. Tate (1997) reported a strong relationship between SES and mathematics achievement and indicated a need to raise achievement for both minority and low SES students. It has been reported that differences in mathematics achievement that is attributed to ethnicity may in fact be due to differences in the SES of the schools (Signer, Beasley, & Bauer, 1997). Further, students' social backgrounds significantly influence their mathematics achievement after controlling for academic ability and orientation toward school (Schiller, Khmelkov & Wang, 2002).

Recommendations and Limitations

It is hoped that at the very least this work can serve to animate research in mathematics education to move beyond the content and begin to focus more on the individual differences and how they impact student performance. Lee (2000) notes that "contexts may be defined by the children's families, the classmates with whom they experience schooling, the peers with whom they choose to interact, and the teachers who instruct them. Students are profoundly influenced by the schools they attend. (p. 140).

One assumption for this study in relation to mathematics achievement was that students were average performers. In addition, limitations were also noted for the present study. One limitation was that there was no randomization due to the students previously being assigned to classrooms resulting in difficulty generalizing the results to a larger population. Other limitations include the subjects agreed to participate meaning they were not randomly chosen; self-report measures which resulted in biased responses from the students; and, the content of the mathematics test. Some of the students were behind in learning the required content and others had not been exposed to the content at all. The format of the mathematics test may perhaps be designed using selected-response items together with constructed-response items to provide students with the chance to explain their answer. Further, a multivariate analysis could be performed to closer examine the relationship between the dependent variables (test score and mathematics grade) and the independent variables (gender, ethnicity, SES) and data could be looked at for differences within the fifth grade group and within the sixth grade group as well as between the two groups.

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Author's Note

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Appendix A
Example Test Items for Mathematics Test

1. Which of these units is the best for measuring the distance between Alabama and Florida?

    A. Inches
    B. Feet
    C. Miles
    D. Yards

2. Chad had one candy bar. He gave 1/3 of it to Ross. How much of it did he have left?

    A. 0/3
    B. 1/3
    C. ½
    D.2/3

3. When Allison was 11 years old, her family moved to Auburn. She went to school there for 11 years until she graduated from college. Since graduation, she has taught for 21 years. How old is Allison?

    A. 21
    B. 32
    C. 43
    D. 54

4. Which number sentence shows the identity property?

    A. 21 + 1 = 24
    B. 23 x 1 = 23
    C. 23 + 10 = 33

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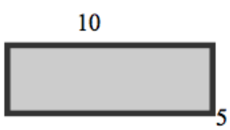

A. 21 + 1 = 24
B. 23 x 1 = 23
C. 23 + 10 = 33
D. 23 x 10 = 230

5. What is the area of the given rectangle?

A. 15 square units
B. 25 square units
C. 30 square units
D. 50 square units

6. Round ½ to the nearest whole number.

A. 0
B. 1
C. 2
D. 3