

# Multiple School-level Inputs and Student Achievement in Science in Urban Georgia High Schools

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**Abstract:** This article focuses on the relationships between eight school-level educational inputs and a measure of student achievement in science as the output. Data were accessed from the Georgia Department of Education's website. Additional quantitative data were collected through interviews with and records from school-level administrators. The study included 28 urban high schools within three metropolitan school districts in the State of Georgia. The data were analyzed using a combination of parametric and non-parametric methods. There was a significant negative relationship between the percentage of economically disadvantaged students (PEDS) and performance in the science section of the Georgia High School Graduation Test (GHS GT). Principal longevity, as a leadership dimension, also showed a significant positive relationship to GHS GT. Although the positive relationships between the numbers of science labs per week and professional development for science teachers and student performance on the GHS GT were not statistically significant at the stringent 0.006  $\alpha$ -level, their effect sizes indicated positive practical significance. Concordancy-discordancy analyses using the Somers' *d* method indicate that 53.5% of the sample schools were discordant. Eight schools performed better than expected given their percentage of economically disadvantaged students (PEDS) values, indicating that other factors beyond student economic status may also contribute to science achievement as measured by the GHS GT.

## Introduction

International comparisons of science achievement for students aged 13 and above ranked the United States in the 13th position (Goldschmidt & Eyer mann, 1999; Zehr, 1998). The U. S. Department of Education's National Center for Education Statistics (NCES) ranked the United States in 15th position on an international comparison in science achievement (U. S. Department of Education, 2003a, Table 409). Another report from the Education Testing Service to the National Assessment of Educational Progress (NAEP) showed that the trend in science performance has been relatively flat over the past decade (U. S. Department of Education, 2003b, Table 127). Former Secretary for Education, Rod Paige, pointed out that 82% of 12th graders are not proficient in science. Paige stated, "It is undisputed that American 12th graders lag far behind their European and Asian counterparts in science, and technology" (U. S. Department of Education, 2003c, p.1). As a result of this trend, 47 states now have academic standards in science; all 50 states have testing programs in science; and 45 states, including Georgia, require

that students demonstrate some acceptable level of performance in science before receiving a high school diploma (U.S. Department of Education, 1999).

Georgia educates over 1.49 million students in about 2,200 schools in 180 school systems (U. S. Department of Education, 2005a). Nationally, Georgia students consistently perform below the proficiency level in the NAEP science test (U. S. Department of Education, 2005b). Since 1997, the trend of student performance on the science section of the Georgia High School Graduation Test (GHS GT) indicates declining performance (Author, 2005). There is also a downward trend in the performance of elementary and middle school students on the science section of the Georgia Criterion-Referenced Competency Test (Agunloye, 2005).

The failure rate in the science section of the GHS GT is the highest of all the subject areas tested. A closer look at the performance of students in the science section of the GHS GT reveals that about 30% of first-time takers (11th graders) fail this section of the test (Georgia Department of Education, 2005). This implies that 30% of the students cannot graduate on time. These potential graduates are often retained one year for remediation and re-testing. On average, about 50% of racial minority students in Georgia fail the science section of the GHST compared with 18% of the racial majority students (Agunloye, 2005). Failure in high school graduation exams is a major reason why students drop out of high school (Eckstein & Noah, 1993). The failure and drop out rates are a serious detriment to bridging the achievement gap and to allowing schools to meet Adequate Yearly Progress (AYP) as required in NCLB.

Heinbuch and Samuels (1995) stated that the relatively poor performance in science is often blamed on lack of qualified teachers, poor instruction, inadequate curriculum, inadequate resources, or combinations of these. Little effort has been made to establish the nature of the relationship between multiple educational inputs and student achievement in science, and only a few studies have looked at the relevance of multiple school-level inputs to student achievement (Agunloye & Sielke, 2007; Coleman, Easton, & LaRocque, 1998; Cooper, Sarrel, Darvas, et. al., 1994; Heinbuch & Samuels; Murnane & Levy, 1996; Murnane & Nelson, 1984).

Coleman, Easton, and LaRocque (1998) reported a distinction between the productive use of resources and the mere presence of such resources in schools and concluded that schools that used available resources effectively showed better and improved student achievement. Rice (1997) disaggregated the costs and outcomes of programs across stakeholders including teachers, students, support services, and administrators. She concluded that each of the stakeholder categories had elements of waste in relation to education costs and student outcomes. Using a two-stage-least-square (2SLS) method, Dee (2004) found that the level of instructional spending is a determinant of student achievement when there is a reduction in less effective cost centers that are not related to instruction.

This study uses 2001-2002 school year data to examine the nature of the relationships between school-level educational inputs and student achievement in science. Eight input variables and one output variable were used in this study. The school-level inputs investigated were: (1) Percentage of Economically Disadvantage Students (PEDS), (2) School-level Science Department Expenditure Per Pupil (SEPP), (3) Science Teacher Quality (STQT), (4) Science Class Size (SCZE), (5) Science Lab-based Instructional Activities per Teacher per Week (LSWK), (6) the number of Professional Development Activities, per Science Teacher per Year (PDST), (7) Principal Longevity (PLGTY) and (8) Head of Science Department Quality (HSQL). The achievement output measure was the percentage of students passing the Science Section of the Georgia High School Graduation Test at first sitting (GHS GT).

## Theoretical Framework and Research Method

The guiding research question for this study was: Is there a relationship between the eight school-level input variables and achievement in science as measured by the percentage of students passing the science section of the GHS GT on first sitting?

This study is a correlational (non-experimental) study that examines the relationship between multiple school-level educational inputs and student achievement in science in high schools. The eight independent variables and the one dependent variable used in this study were examined closely for contextual significance to instruction and outcome expectations in science education.

### *Percentage of Economically Disadvantaged Students (PEDS)*

The first independent variable is the percentage of economically disadvantaged students (PEDS). The percentage of students eligible for the federal free and reduced lunch program was used as a proxy measure of the socio-economic status of students. These data were available on the Georgia Department of Education's (GADOE) website. Many research studies of education productivity have used the socio-economic status of students as a factor (Alexander, 1997; Figlio 1999; Hanushek, 1986, 1989, 1991; Mancebon & Bandres, 1999; Monk, 1992; Walberg, 1982). In a more extensive study of the effects of socio-economic status on students achievement in science, when considered alone and in interaction with other factors, Von Secker (2004) found that SES has the highest estimated effect size (0.65) on student achievement. The next highest effect size was the interaction between SES and parent education (0.13), followed by the interaction effect of SES and home environment on student achievement in science, which was very minimal (0.04). PEDS was therefore considered a relevant variable to student performance in science.

### *School-level Science Department Expenditure Per Pupil (SEPP)*

The second independent variable was the per pupil science expenditure at the school level. The issue of the relationship between money and student achievement has been the subject of debate for decades. While some researchers (Coleman, 1968; Hanushek, 1997; Unnever, Kerckhoff, & Robinson, 2000) believe that money does not matter; others (Greenwald, Hedges, & Laine, 1996; Klick 2000; Mancebon & Bandres, 1999; Monk, 1992; Tatsouka, 1988; Walberg, 1982; Walberg & Fowler, 1989; Walberg & Weistein, 1982; Weglinsky, 1997) believe that money does matter. The (Agunloye & Sielke, 2007) found that money matters in measuring the achievement of students in science only after the SES, as measured by free and reduced lunch eligibility, is taken into consideration.

Science demands hands-on activities that require the use of specialized equipment and materials. SEPP was measured by the amount of money received by the science departments in the sample schools for hands-on activities. The numeric values for SEPP data were computed by dividing direct amounts of money actually received by the science department, per academic year, by the total number of students in each of the sample schools. For example if the science department received \$5,000 per academic year towards direct science instruction in the classroom in a school with 1,500 enrolled students, then the  $SEPP = \$5,000/1,500 = \$3.33$  per pupil. The total number of students in each school was used because every Georgia high school

student has to take science classes and pass the science section of the Georgia High School Graduation Test to get a high school diploma from their respective schools. The amount of money received by the science departments was verified through a two-step process. First, the science department head was interviewed regarding the amount his/her science department received for the 2001-2002 school year. Next, the amount was cross-checked with the bookkeeper's records. In the case of a discrepancy, the bookkeeper's numbers were used.

### *Science Teacher Quality (STQT)*

The third independent variable was science teacher quality. According to Ingersoll (1999) 20% of secondary grade teachers do not hold a degree in their assigned fields. The debate on what constitutes teacher quality in the specific subject areas remains unresolved (Haertel, 1991; Ingersoll, 1999). Research indicates a strong positive correlation between the amount of teacher course preparation in science and the level of student achievement (Darling-Hammond, 2000). The NCLB Act requires that states guarantee that teachers of science have completed a bachelor's degree in the core subject of teaching assignment, hold full certification, and pass rigorous subject content and pedagogy tests to demonstrate competence in the assigned subject. In Georgia about 3,000 high school teachers have a main teaching assignment in science (Council of Chief State School Officers, 2005). A measure of the impact of science teacher quality on student achievement is therefore necessary. However, the measure of teacher quality in this study does not include consideration for teaching assignment in the subject of college major.

The numeric values for STQT data were obtained using the transformation process detailed in Appendix A using both highest degree and number of years in the teaching profession. The data on qualification and experience for science teachers in the sample schools were obtained during the interview with the science department head.

### *Science Class Size (SCZE)*

The fourth independent variable was class size, defined as the number of students for whom the teacher is responsible for each science class period (Finn & Achilles, 1999). In this study, science class size (SCZE) is measured as the average number of students assigned to an individual teacher per science class period over a school year. Several studies have been published on the effects of class size on student performance (Finn & Achilles; Glass & Smith, 1978; Glass, Cohen, Smith, & Filby, 1982; Robinson, 1990; Robinson & Wittebols, 1986; Slavin, 1989). The studies opined that class size could affect academic achievement, although significant benefits from small class sizes are obtained only below a critical number. For example, in elementary schools a class size of 18 has been shown to produce significant benefits for students from economically disadvantaged backgrounds (Robinson, 1990; Robinson & Wittebols, 1986; Slavin).

The peculiar nature of science instruction, requiring laboratories and hands-on modules, makes the issue of class size an important consideration. The numerical values for SCZE data were the average number of students per science class per teacher for the 2001-2002 academic year.

### *Science Lab-based Instructional Activities per Teacher per Week (LSWK)*

The fifth independent variable used in this study was the number of lab-based instructional activities per teacher per week (LSWK). Science students, who have hands-on activities at least once a week, have been shown to perform above the proficiency level of those who do not have hands on activities (O'Sullivan & Weiss, 1996). Students in 4th and 8th grades tend to score higher in the science section of the National Assessment of Educational Progress (NAEP) when they have experienced hands-on and project centered science instruction (Wenglinsky, 2004). The numeric values for LSWK were the average number of laboratory-based hands-on activities per week per science teacher. The data for this variable were obtained through the interviews with the science department heads.

### *Professional Development Activities, per Science Teacher per Year (PDST)*

The sixth independent variable was the average number of professional development activities attended by science teachers in the sample schools. Researchers have found that science educators often lack sufficient content knowledge and instructional strategies in the absence of relevant professional development (Darling-Hammond & McLaughlin, 1995; Darling-Hammond, Wise, & Klein, 1995). The Carnegie Commission on Science, Technology, and Government (1991) advocated for professional development programs to enhance the content knowledge and teaching skills of science teachers.

Professional development for science teachers is not only necessary to meet the requirements of the NCLB Act but also may bear a relationship to student achievement in science. The numeric values for PDST were the number of professional staff development events attended per science teacher during the 2001-2002 academic year in each of the sample schools. The data did not indicate the content of the professional development activities. Professional development for science teachers is not only necessary to meet the requirements of the NCLB Act but also may bear a relationship to student achievement in science.

### *Principal Longevity (PLGTY)*

The seventh independent variable is the principal's longevity in the capacity of principal in the sample school (PLGTY). Principal's longevity is a leadership dimension that may contribute to a culture and climate conducive for learning (Argyris, 1993). Studies have shown that there is a link between principal longevity and student achievement in general (Aaronson, 1999; Comber & Kreeves, 1973; Marzano, Waters, & McNulty, 2005). The combination of suitable climate, instructional focus, and visionary leadership may contribute to improved achievement in science. The Adequate Yearly Progress requirement of the NCLB indirectly holds school leadership accountable for the performance of schools, especially in the core subject areas of science, math, language arts, and social studies. This makes the issue of school leadership an important input in the education accountability equation with implications for science education. The numeric values for PLGTY were the number of years a principal had served in that capacity in the sample school. Data were obtained during the interviews with the principal and science department head.

### *Head of Science Department Quality (HSQL)*

The eighth, and final, independent variable is the quality of the science department head. Principals and other higher school-level administrators often have little or no background content/instructional experience in science. Therefore, they rely on the judgments and leadership of science department heads who are not only supposed to be highly content knowledgeable in science but also, and perhaps most importantly, instructional leaders for the department. The quality of the science department head is therefore an important factor that may have some influence on the performance of students. No reported research was found on the relationship between science department chair quality and students achievement.

The numeric values for HSQL were computed using the formula

$$\text{HSQL} = Y_t \times 2(Y_{hod}),$$

where:  $Y_t$  is the number of years as a teacher before becoming head of science department, and  $Y_{hod}$  is the number of years as head of science department. The number of years as head of science department is weighted by an arbitrary factor of 2, relative to the number of years as science teacher because the responsibilities as head of the science department carry more weight than the responsibilities as a science teacher. NCES suggests using a weighing factor in their index of teacher quality (U.S. Department of Education, 2002b). Moreover, almost all science department heads have teaching responsibilities in addition to their responsibilities as heads of the science departments. Thus, it was assumed that the position as head of department is worth twice as much as the position of teacher. For example, the calculation for a head of department who has 10 years as a teacher before becoming head of department ( $Y_t$ ) and has served 5 years as head of department ( $Y_{hod}$ ) would be  $\text{HSQL} = 10 \times 2(5) = 100$ . Data for the calculation of science department head quality were obtained from the principal and science department head for the 2001-2002 year.

### *Georgia High School Graduation Science Tests (GHSGT)*

The dependent variable in this study was student performance on the science portion of the Georgia High School Graduation Test (GHSGT). In Georgia a student is required to pass three science courses (biology, physical science, and either chemistry or environmental science) and pass the science section of the Georgia High School Graduation Test (OCGA 20-2-281). Thus, performance on the GHSGT is an important measure of educational output. The percentage of students passing the science portion of the GHSGT on first sitting was used for the sample schools. Data on GHSGT for school year 2001-2002 were obtained from the state's Office of Student Achievement (OSA) archival data records.

### *Sampling and Interview Survey*

Twenty-eight schools in three school districts within the Atlanta metropolitan area participated in the study. The school sampling selection criteria were based on the number of high schools in the districts with complete state performance and financial report records for two consecutive years covering school years 2000-2001 and 2001-2002 on all the variables

considered. Where possible, FY2001 and FY2002 data from the Georgia Department of Education (2002, 2003) were used. However, GADOE collects only district level data. To obtain school level data, interviews were conducted with the principals, science department heads, and bookkeepers in each of the schools to collect fiscal and demographic data not already available and to verify information from pre-existing reports.

### *Analytical Method*

Both parametric and non-parametric statistical methods were used to investigate the nature of the relationships between the eight school-level input variables and the output measure. Pearson's product moment correlation (a parametric statistic) and Kendall's tau-b (a non-parametric statistic) were used to establish the magnitude and the direction of the relationships between the input variables and the output measure. Schools were then grouped into performance categories and ranked using Somers' *d* non-parametric statistic.

Pearson's product moment correlation and Kendall's tau-b measured the magnitude and direction of the relationship between GHSGT on one hand, and each of the input variables, on the other hand. Somers' *d* measured the degree of concordance-discordance between GHSGT and each of the eight input variables. Kendall's tau-b was used in conjunction with Pearson's product moment correlation to show that similar inferences were possible from the two statistics despite the fact that Kendall's tau-b is a non-parametric measure useful in situations where sample size is relatively small compared to the number of dependent variables while Pearson's product moment correlation is a parametric statistic used for relatively large sample size. Both statistics are reported to show that there is consistency between the two measures to validate the reliability of the inferences made despite sample size limitation.

Given the sample size limitation of 28 relative to the number of dependent variables examined (eight), the Bonferoni approach was used to control for Type I error across the eight input variables. A p-value of less than .006 ( $.05/8 = .006$ ) was required for statistical significance. Therefore, a stringent alpha-level for significance was set at 0.006 to ensure a very conservative test and improve the reliability the findings.

### **The Findings**

The descriptive statistics, including the low, high, mean, skewness, and standard deviation for each of the eight input and the single output variables considered are shown in Table 1.

The standard variation (SD) values indicate little variation in class size ( $M = 25.82$ ,  $SD = 2.06$ ) across schools (Table 1). There was significant variation in SEPP ( $M = 5.18$ ,  $SD = 4.46$ ). The range in science spending per pupil is \$22.29, confirming that some schools are spending a relatively higher amount per pupil in their science departments than the other schools. In one particular school, the science department gets a sizable amount of money, \$23.00 per pupil while another school is receiving only \$.51 per pupil. All values were included in the analysis, even when they appear as outliers. The skewness values for the remaining variables indicate no significant variation.

Table 1

Descriptive Statistics of School-Level Inputs and Outputs

| Variables* | High | Low  | M     | SD    | Skewness | N** |
|------------|------|------|-------|-------|----------|-----|
| PEDS       | 84.0 | 16.2 | 42.92 | 18.77 | 0.623    | 28  |
| SEPP       | 23.8 | .051 | 5.18  | 4.47  | 2.908    | 28  |
| STQT       | 73.3 | 33.9 | 43.94 | 8.58  | 1.800    | 28  |
| SCZE       | 28.0 | 21.0 | 25.82 | 2.06  | -0.540   | 28  |
| LSWK       | 4.0  | 1.0  | 1.46  | 0.69  | 1.935    | 28  |
| PDST       | 6.0  | 1.0  | 2.61  | 1.31  | 0.907    | 28  |
| PLGTY      | 13.0 | 1.0  | 3.12  | 2.63  | 2.414    | 26  |
| HSQL       | 58.0 | 7.0  | 24.96 | 11.33 | 0.709    | 28  |
| GHSQT      | 80.5 | 34.0 | 64.57 | 14.30 | -0.397   | 28  |

\*Variables are the eight inputs and one output at the school-level

\*\*N= number of schools

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Using the Bonferoni approach to control for Type I error across the eight input variables, a p-value of less than .006 ( $.05/8 = .006$ ) was required for statistical significance. The inferential analysis indicates that there were no significant correlations between each of the eight school-level input variables and achievement output measure. The nature of the relationships between GHSQT and the eight input variables are summarized in Table 2.

Table 2

Correlations Between GHSQT and School Level Inputs

| Variables    | Pearson's Correlation R) |             |      | Kendall's tau-b |             |      | $\eta^2$ |
|--------------|--------------------------|-------------|------|-----------------|-------------|------|----------|
|              | Value                    | Statistic T | P    | Value           | Statistic T | P    |          |
| GHSQT*PEDS   | -.971*                   | -6.594      | .000 | -.537*          | -4.312      | .000 | 1.000    |
| GHSQT*SEPP   | -.091                    | -0.464      | .081 | .035            | 0.233       | .102 | .990     |
| GHSQT*STQT   | -.094                    | -0.480      | .078 | -.027           | -0.189      | .106 | .990     |
| GHSQT*SCZE   | .183                     | 0.950       | .118 | .133            | 0.797       | .536 | .406     |
| GHSQT*LSWK   | .240                     | 1.258       | .027 | .214            | 1.421       | .019 | .059     |
| GHSQT*PDST   | .123                     | 0.631       | .067 | .024            | 0.164       | .109 | .151     |
| GHSQT*PRLGTY | .463*                    | 3.326       | .001 | .486*           | 3.345       | .001 | .625     |
| GHSQT*HSQL   | .079                     | 0.405       | .086 | .041            | 0.305       | .095 | .658     |

\*Significant at  $p < .006$  after controlling for family-wise error for the eight input variables

The correlation coefficients computed indicate that only two out of the eight input variables showed statistically significant linear relationships with GHSGT at the tested Bonferoni  $\alpha$ -level level. There was a highly statistically significant negative correlation between GHSGT and PEDS (Pearson's  $R = -.971$ ,  $t(27) = 6.594$ ,  $p < .001$ , Kendall's tau-b =  $-.537$ ,  $t(27) = 4.312$ ,  $p < .001$ ); The variance in PEDS explained about 100% of the variance in GHSGT ( $\eta^2 = 1.00$ ). The positive correlation between GHSGT and PLGTY was also statistically significant (Pearson's  $R = .463$ ,  $t(27) = 2.560$ ,  $p = .002$ , Kendall's tau-b =  $0.486$ ,  $t(27) = 3.345$ ,  $p = .001$ ); GHSGT as a dependent variable in relation to PLGTY explained almost 62.5 % of the relationship ( $\eta^2 = 0.625$ ).

There was also a positive correlation between GHSGT and LSWK (Pearson's  $R = .240$ ,  $t(27) = 1.258$ ,  $p = .027$ , Kendall's tau-b =  $0.214$ ,  $t(27) = 1.421$ ,  $p = .019$ ), but the correlation was not statistically significant at the stringent Bonferoni test level of .006. GHSGT as a dependent variable explained only 5.9 % of the relationship ( $\eta^2 = 0.059$ ) with LSWK. However, given the sample size and the stringent Bonferoni alpha level of .006 for the tests, the positive correlation between GHSGT and LSWK (.240) is of practical significance.

Further analysis investigated the nature of PEDS influence on GHSGT. For this analysis, the schools were ranked in descending order of their values on the GHSGT compared to their corresponding PEDS values. A directional measures test, using Sommer's  $d$ , was performed to determine the extent of concordance or discordance between the GHSGT values and their corresponding PEDS values for each of the 28 schools. The results of the Somer's  $d$  test indicated that 15 of the 28 sample schools (53.5%) were discordant. Eight of these 15 schools were positively discordant, while the remaining seven schools were negatively discordant (Sommer's  $d = -0.537$ ,  $t(27) = 4.312$ ,  $p < .001$ ). The rest of the sample schools (13) were concordant. Based on the concordancy results, the schools were grouped into three categories (see Table 3), labeled as "positively discordant schools," "concordant schools," and "negatively discordant schools."

The first category, "positively discordant schools" includes schools that performed above expectation on the GHSGT compared to their PEDS values; these schools had relatively high GHSGT values despite their relatively unfavorable high PEDS values. The second category, "concordant schools," includes schools that performed according to expectation compared to their PEDS values. The third category, "negatively discordant schools," includes schools that performed below expectation compared to their PEDS values; these were schools with relatively low GHSGT values given their relatively favorable low PEDS values.

### *The Limitations of the Study*

Student performance in science on the GHSGT is only one measure of student performance. This measure alone may not have captured the complete picture of science performance of the sample schools. The eight independent variables selected do not comprise an exhaustive list of all the variables that could impact science achievement. Other variables not considered in this study may also have equal or more significance to student achievement in science as the eight selected variables. The quantitative and qualitative data collected are specific to the sample schools. The results and inferences from this study are therefore situational and may not be widely generalizable, except in situations that are very similar to the ones in this study. Because of the non-experimental nature and the quantitative aspects of this study, cause and effect inferences also may not be made.

Table 3

GHSGT Ranking and Concordancy Grouping Relative to PEDS

| GHSGT Ranking | GHSGT | PEDS  | Positively Discordant | Concordant | Negatively Discordant |
|---------------|-------|-------|-----------------------|------------|-----------------------|
| 1             | 91.00 | 17.50 |                       | **         |                       |
| 2             | 82.00 | 18.05 |                       | **         |                       |
| 3             | 80.50 | 48.75 | +ve                   |            |                       |
| 4             | 79.50 | 30.50 | +ve                   |            |                       |
| 5             | 78.50 | 16.20 |                       |            | -ve                   |
| 6             | 77.00 | 45.45 | +ve                   |            |                       |
| 7             | 76.00 | 46.10 | +ve                   |            |                       |
| 8             | 75.50 | 31.20 | +ve                   |            |                       |
| 9             | 72.00 | 27.15 |                       | **         |                       |
| 10            | 72.00 | 25.80 |                       | **         |                       |
| 11            | 71.50 | 28.45 |                       | **         |                       |
| 12            | 70.50 | 38.50 |                       | **         |                       |
| 13            | 70.00 | 44.65 | +ve                   |            |                       |
| 14            | 69.50 | 29.75 |                       |            | -ve                   |
| 15            | 69.50 | 28.70 |                       |            | -ve                   |
| 16            | 66.50 | 33.65 |                       |            | -ve                   |
| 17            | 61.00 | 49.85 |                       | **         |                       |
| 18            | 61.00 | 55.60 | +ve                   |            |                       |
| 19            | 60.00 | 36.63 |                       |            | -ve                   |
| 20            | 57.00 | 42.00 |                       | **         |                       |
| 21            | 54.00 | 58.50 | +ve                   |            |                       |
| 22            | 51.00 | 26.30 |                       |            | -ve                   |
| 23            | 49.50 | 52.90 |                       | **         |                       |
| 24            | 48.50 | 75.05 |                       | **         |                       |
| 25            | 45.00 | 75.35 |                       | **         |                       |
| 26            | 45.00 | 74.20 |                       | **         |                       |
| 27            | 40.50 | 61.20 |                       |            | -ve                   |
| 28            | 34.00 | 84.00 |                       | **         |                       |

*a* = (+ve) schools performing significantly above expectation compared to their PEDS values.

*c* = (\*\*) schools performing according to expectation compared to their PEDS values.

*b* = (-ve) schools performing significantly below expectation compared to the PEDS values.

Somers' *d* = -0.537, *T* = -4.312, *α* = .05, <.001.

% Discordancy = 53.57%.

## Discussion

Two input variables, student economic status (PEDS) and principal longevity (PLGTY) have a statistically significant correlation with the output measure, passage of the science portion of the Georgia High School Graduation Test at first sitting (Table 2). There was a positive correlation between principals' stability, as measured by the number of years a principal has spent in a school, and student achievement. The positive link may be related to the immaturity-maturity continuum concept posited by Argyris (1993). As principals become more experienced, their organizational maturity increases, and they are better able to align their vision and the educational expectations with the core content areas. Stable principals are more likely to have time to create climates and cultures conducive to learning. The combination of suitable climate, instructional focus, and visionary leadership may contribute to improved achievement in science. In their review of studies across 14 countries in the 1960s, Comber and Kreeves (1973), indicated that school environment modifies students' habits and, on the aggregate, predicts student scores in science across these countries.

There was also a significant negative relationship between GHSGT and PEDS (see Table 2). The strength of this relationship reinforces the need to recognize and address the economic status of students as an integral part of educational input. This finding shows that economically deprived students may require more resources if they are to show significant gains in science performance.

The lack of a statistically significant relationship between science department expenditure per pupil and student achievement in science, at the school level, may be due to the relatively small proportion of direct instructional money, per pupil, allocated to science departments, compared to Georgia's Quality Basic Education (QBE) funding allotment to the school as a whole (see Table 2). The mean expenditure of \$5.18 per high school pupil in regular classes constitutes only 0.19% of the average QBE allotment funding across schools. Given the material and equipment requirements of science instruction, this is a relatively small amount of instructional money to make any impact on student achievement in science. A special weighting for science labs under QBE funding was eliminated in FY2001. Therefore, science, given its special needs compared to other subject disciplines, is under-funded in Georgia schools.

The non-significant relationship between teacher quality and the percentage of students passing the science section of the GHSGT at first sitting has practical implications (see Table 2). A highly specialized academic discipline such as science requires teachers with specialization in the specific subject areas. One of the main concerns in science education has been that science educators often lack sufficient content knowledge (Monk, 1992). Monk reported a positive relationship between student achievement and the number of courses teachers had taken in the subjects they taught.

In recent years there has been concern about the increasing number of science teachers who teach out of the subject-field of their specialization (U.S. Department of Education, 2002b). The usual research measures of teacher quality, degrees and experience, were combined in this study. Although all the science teachers in the schools studied had degrees in science, consideration was not given to specialization within a science area. Therefore the measure of teacher quality, as a composite of experience and highest academic qualification, may not be an effective measure that impacts student achievement in science.

The statistically non-significant relationship between science class size and student achievement may be due to the small variability in science class size across schools (see Table

2). The mandated maximum class size for science in the state of Georgia is 28 students. As shown in this study, the average science class size was 25.82 students. Research has shown that the benefits of smaller class sizes only become significant at class levels between 17 and 20 and for students in the lower grades (Finn & Achilles, 1999; Grissmer, 1999; Mostella, 1995; Word et al., 1990). However, because of the specialized nature of science instruction, requiring hands-on activity, a lower class size may have an impact on science instruction. A reduction in class size requires additional teachers and possibly additional labs and hence, additional expenditure.

Although the positive relationship between the number of lab-based activities per week and student achievement is statistically non-significant at the very stringent alpha-level (0.006), the value of the correlation coefficient is high enough to be of practical significance (see table 2). Previous research by O'Sullivan and Weiss (1996) reported that the majority of high school students who did hands-on lab-based activities at least once a week were more likely to perform above a proficiency level than those who did not. The finding of this study tends to agree with this earlier finding. Increasing the number of hands-on labs per week and increasing materials for the lab activities coupled with staff development on inquiry-based instructional activities may strengthen the relationship of spending to achievement. As Irving, Dickson, and Keyser (1999) noted that the quality science instruction needs significant improvement in order to make significant gains in student achievement.

The relationship between the number of professional development activities per science teacher per academic year and the measure of student achievement was not statistically significant; however the value of the correlation coefficient was high enough at the stringent test alpha-level (0.006) to be of practical significance (see Table 2). This finding agrees with those reported by the Council for School Performance (1994) indicating a positive relationship between staff development and student achievement in Georgia public schools.

According to Stofflett and Stoddart (1994) professional development that emphasizes constructivist practices that merge content knowledge with appropriate and relevant practical hands-on activities is the key to making a difference in improving student science achievement. The U.S. Department of Education, (2002b) reported that only 40% of full-time teachers indicated participation in professional development that focused on in-depth study in their main teaching field. There is, therefore, a need to ensure that the type and quality of professional development for science teachers matches their pedagogical assignments and their content focus.

The findings of this study showed possible indications of other school-level factors beyond money and economic factors that affect student achievement in science (see table 3). There were schools that had high percentages of economically disadvantaged students and yet performed above expectation; these are the "positively discordant schools." There were also schools that had low percentage of economically disadvantaged students and yet performed below expectation. These are the "negatively discordant schools." Therefore, socioeconomic status, as defined by the percentage of economically disadvantaged students, and other quantitative inputs, may not be the only variables responsible for variations in the student achievement measures across the schools considered in this study.

In his study of allocative efficiency, Aaronson (1999) used extensions of the Data Enveloping Analysis (DEA) to identify effective schools relative to resource allocation and utilization. He associated attendance, stable leadership, stable student population, and school climate with effective schools. Further study of the types and nature of the factors that may impact student achievement at the individual school level, beyond money, is suggested.

## Conclusion

In conclusion, this study has shown that:

- The economic status of the student population in a school bears significant relationship to achievement in science.
- The number of hands-on laboratory-based activities has a positive relationship to student achievement in science.
- Principal's longevity bears a significant relationship to achievement in science.
- The money that goes directly to science departments for science instruction at the school-level is small and may not be at a level that produces any significant relationship to student achievement in science.
- Non-financial factors may also impact on achievement in science given the fact that only 13 of the 28 schools were concordant.

The poor performance of Georgia students on state and national tests should signal a need to examine the resources that are available for high school science education. The fact that passage rate of the science section of the GHSGT is often the lowest compared to other content areas, additionally calls for the need to look at resources for science. From a policy perspective, increases in funding might impact and improve student performance in science. Such additional funding might be used to not only purchase additional supplies and equipment but also be used for professional development for teachers in their specific content area.

The finding of a significant relationship between principal longevity and science achievement needs further examination. Stable leadership is important to reform and stable and good leadership seems to be important in improving schools with high levels of poverty. Policy makers need to develop ways to attract and retain highly qualified administrators and teachers to address the achievement gaps between low SES and higher SES students. Additional funding would support more supplies and equipment, targeted professional development for teachers, and incentives to attract and retain high quality teachers and leaders.

## References

- Aaronson, D. (1999). The effects of school finance reform on population heterogeneity. *National Tax Journal*, 52(1), 5-29. Available: <http://proquest.umi.com>.
- Agunloye, O. O. (2005). Improving performance in science: Need for shifts in perception, policy, and practice. *Paper presented at the 2005 Annual Fall Superintendents Conference, Pioneer RESA, Lake Lanier, Gainesville, Georgia, USA*. October 13, 2005.
- Agunloye, O. O., & Sielke, C. C. (2007). A multivariate analysis of educational productivity in urban Georgia high schools. *Georgia Educational Researcher*, 5. Online journal. Available: <http://coefaculty.valdosta.edu/lshmert/gera/volume%205/multivariate-finalbyLS2007.pdf>.
- Alexander, K. L. (1997). Public schools and public good. *Social Forces*, 76(1), 1-30.
- Argyris, C. (1993). *The individual and the organization: Some problems of mutual adjustment*. New York: Irvington.
- Carnegie Commission on Science, Technology and Government. (1991). *In the national interest: The federal government in the reform of K-12 math and science education*. New York: Author.
- Coleman, J. S. (1968). The concept of educational opportunity. *Harvard Educational Review*, 38(7), 7-22.
- Coleman, P., Easton, S., & LaRocque, L. (1998). Reconciling equity and excellence: Resource allocation in school districts. In W. T. Hartman & W. L. Boyd (Eds.), *Resource allocation and productivity in education*. (pp 101-128). Westport, CT: Greenwood.
- Comber, L. C., & Keeves, J. P. (1973). *Science education in nineteen countries: An empirical study*. Stockholm: Wiley.
- Cooper, B. S., Sarrel, R., Darvas, P., Alferno, E., Samuels, J., & Heinbuch, S. (1994). Making money matter in education: A micro-financial model for determining school-level allocations, efficiency, and productivity. *Journal of Education Finance*, 20(1), 66-87.
- Council of Chief State School Offices, CCSS (2005). Rol K. Blank & Doreen, Langesen (Eds.). *State Indicators of science and mathematics education, 200: State-by-state trends and national indicators*. Washington, DC: Council of Chief State School Officers.
- Council for School Performance. (1994). Effect of staff development on student achievement in Georgia. Available: [http://www.arc.gsu.edu/cps/cps\\_geogiahope.htm](http://www.arc.gsu.edu/cps/cps_geogiahope.htm)
- Darling-Hammond, L. (2000). *Solving the Dilemmas of Teacher Supply, Demand, and Standards: How We Can Ensure a Competent, Caring, and Qualified Teacher for Every Child*. New York, NY: National Commission on Teaching and America's Future.

- Darling-Hammond, L., & McLaughlin, M. (1995). Policies that support professional development in an era of reform. *Phi Delta Kappan*, 76, 389-392.
- Darling-Hammond, L., Wise, A. E., & Klein, S. P. (1995). *A license to teach: Building a profession for 21st-century schools*. Boulder, CO: Westview Press.
- Dee, T. S. (2004). Expense preference and student achievement in school districts. *Eastern Economics Journal*, 3(1), 23-44. Available: <http://web2.epnet.com/citation>.
- Eckstein, M. A., & Noah, H. J. (1993). *Secondary school examinations: International perspectives on policies and practice*. Cumberland, RI: Yale University Press.
- Figilo, D. N. (1999). Functional form and estimated effects of school resources. *Economics of Education Review*, 18, 241-252.
- Finn, J. D., & Achilles, C. M. (1999). Answers and questions about class size: A statewide experiment. *American Educational Research Journal*, 27, 557-557.
- Georgia Department of Education (2002). *2000-2001 Georgia public education report card, State of Georgia*. Atlanta, GA: Office of Educational Accountability, GA Department of Education. Author.
- Georgia Department of Education (2003). *2001-2002 Georgia public education report card, State of Georgia*. Atlanta, GA: Office of Educational Accountability, GA Department of Education. Author.
- Georgia Department of Education (2005). *Georgia public education report card, State of Georgia*. Atlanta, GA: Office of Educational Accountability, GA Department of Education. Author.
- Glass, G. V., Cohen, L. S., Smith, M. L., & Filby, N. N. (1982). *School class size research and policy*. Beverly Hills, CA: Sage.
- Glass, G. V., & Smith, M. L. (1978). *Meta-analysis of research on the relationship of class size and achievement*. San Francisco: Far West Laboratory for Educational Research and Development.
- Goldschmidt, P., & Eyermann, T. S. (1999). International education performance of the United States: Is there a problem that money can fix? *Comparative Education*, 35(1), 27-43. Available: [www. http://www.gallelio.org/pqweb](http://www.gallelio.org/pqweb).
- Greenwald, R., Hedges, L. V. & Laine, R. D. (1996). The effects of school resources on student achievement. *Review of Educational Research*, 66(3), 361-396.
- Grissmer, D. (1999). Class size effects: Assessing the evidence, its policy implications, and future research agenda. *Educational Evaluation and Policy Analysis*, 21, 321-248.

- Heartel, E. (1991). New forms of teacher assessment. In G. Grant (Ed.), *Review of Research in Education* (pp. 3-29). Washington, DC: American Educational Research Association.
- Hanushek, E. A. (1986). The economics of schooling: Production and efficiency in public schools. *Journal of Economic Literature*, 24, 1141-78.
- Hanushek, E. A. (1989). The impact of differential expenditures on school performance. *Educational Researcher*, 18(4), 45-65.
- Hanushek, E. A. (1991). When school finance reform may not be a good policy. *Harvard Journal of Legislation*, 28, 423-456.
- Hanushek, E. A. (1997). Assessing the effects of school resources and student performance: An update. *Educational Evaluation and Policy Analysis*, 19, 141-164.
- Heinbuch, S. E., & Samuels, J. A. (1995). Getting more bang for the education buck. *Public Productivity & Management Review*, 18(3), 233-342. Available: <http://proquest.umi.com>.
- Ingersoll, R. (1999). The problem of underqualified teachers in American secondary schools. *Educational Researcher*, 28(3), 20-31.
- Irving, M. M., Dickson Jr., L. A. & Keyser, J. (1999). Retraining public secondary teachers by updating their content knowledge and pedagogical skill. *Journal of Negro Education*, 68(3), 409-419. Retrieved August 24, 2003 from <http://proquest.umi.com>.
- Klick, J. (2000). Do dollars make a difference? The relationship between expenditures and test scores in Pennsylvania's schools: *American Economist*, 44(1), 81-87. Available: <http://proquest.umi.com>.
- Mancebon, M., & Bandres, E. (1999). Efficiency evaluation in secondary schools: The key role of model specification and of ex post analysis of results. *Education Economics*, 7(2), 131-152. Available: [www.pqweb.org](http://www.pqweb.org)
- Marzano, R. J., Waters, T., & McNulty, B. A. (2005). *School leadership that works: From research to results*. Alexandria, VA: ASCD.
- Monk, D. H. (1992). Education resources for improving schools: A case study of teacher allocation in Boston Public Schools. *Education Evaluation and Policy Analysis*, 14, 307-332.
- Mostella, F. (1995). The Tennessee study of class size in the early school grades. *The Future of Children*, 5, 113-127.
- Murnane, R. J., & Levy, E. (1996). *Why money matters sometimes*. New York: Free Press.

Murnane, R. J., & Nelson, R. R. (1984). Production and innovation when techniques are tacit. *Journal of Economic Behavior and Organization*, 5, 353-373.

Official Code of Georgia Annotated (2000). *OCGA*, 20-2-86.

O'Sullivan, C., & Weiss, A. R. (1996). Student work and teacher practices in science. *Education Statistics Quarterly*, U.S. Department of Education, NCES, Washington, DC: U.S. Government Printing Press.

Rice, J. K. (1997). The impact of class size on instructional strategies and the use of time in high school mathematics and science courses. *Education Evaluation and Policy Analysis*, 21, 215-229.

Robinson, G. E. (1990). Synthesis of research on effects of class size. *Educational Leadership*, 47(7), 80-90.

Robinson, G. E., & Wittebols, J. H. (1986). *Class size research: A related cluster analysis for decision making*. Arlington, VA: Educational Research Service.

Slavin, R. E. (1989). Achievement effects of substantial reductions in class size. In R. E. Slavin (ed.), *School and classroom organization* (pp. 247-257). Hillsdale, NJ: Erlbaum.

Stofflett, R. T., & Stoddart, T. (1994). The ability to understand and use conceptual pedagogy as a function of prior content learning experience. *Journal of Research in Science Teaching*, 30(1), 31-51.

Tatsuoka, M. M. (1988). *Multivariate analysis: Techniques for educational and psychological research*. New York: Macmillan.

Unnever, J. D., Kerckhoff, A. C., & Robinson, J. J. (2000). District variations in education resources and student outcomes. *Economics of Education Review*, 19(3), 245-259.

U. S. Department of Education, NCES. (1999). *The condition of education 1999*. (NCES 1999-022). Washington, DC: US Government Printing Office. Author.

U. S. Department of Education, NCES. (2002). *Schools and staffing survey, 1999-2000* (NCES 2002-313). Washington, DC: US Government Printing Office. Author.

U. S. Department of Education, National Assessment of Educational Progress, NAEP. (2003a). *Digest of Education Statistics: The Trend in International Mathematics and Science Study (TIMSS)*. Washington, DC: US Government Printing Office. Author.

U. S. Department of Education, National Assessment of Educational Progress, NAEP. (2003b). *Trends in academic progress, various years*. Washington, DC: US Government Printing Office. Author.

- U.S. Department of Education, (2003c). Secretary's Summit On Mathematics, Science, & Technology. *Secretary's Remarks at Mathematics, Science and Technology Initiative, Speech, U.S Department of Education*, p.1.
- U.S. Department of Education, (2005a). *Common Core of Data, CCD*. Washington, DC: US Government Printing Office. Author.
- U. S. Department of Education, National Assessment of Educational Progress, NAEP. (2005b). *Trends in academic progress, various years*. Washington, DC: US Government Printing Office. Author.
- Von Secker, C. (2004). Science achievement in school contexts: Analysis from National Assessment of Educational Progress. *Journal of Education Research*, 98(2), 67-78. Retrieved November 5, 2005 from <http://web2.epnet.com/citation>.
- Walberg, H. J. (1982). Education productivity: The theory, evidence, and prospects. *Australian Journal of Education*, 26(2), 115-122.
- Walberg, H. J., & Fowler, W. J. (1989). Expenditure and size efficiencies of public school districts (Report No. Rc-015-786). East Lansing, MI: National Center for Research on Teacher Learning. (ERIC Document Reproduction Service No. ED 274471).
- Walberg, H. J. & Weinstein, T. (1982). The production of achievement and attitude in high school social studies. *Journal of Educational Research*, 75(5), 285-292.
- Wenglinsky, H. (1997). School district expenditures, school resources, and student achievement: Modeling the production function. In W. J. Fowler (Ed.), *Developments in school finance, 1997-1998* (pp. 99-120). Washington, DC: U.S. Department of Education, National Center for Education Statistics.
- Wenglinsky, H. (2004). Facts or critical thinking skills? *Education Leadership*, 62(1), 32-35.
- Word, E., Johnson, J., Bain, U., Fulton, D. B., Boyd-Zaharias, J., Lintz, M. N., et. al. (1990). *Student/Teacher Achievement Ratio (STAR): Tennessee's K-3 class size study*. Nashville: Tennessee Department of Education.
- Zehr, M. A. (1998). Weak scores, strong economy: How can this be? *Education Week*, 17(29), 1-20.

## APPENDIX

### Example of Transformation Calculation for Teacher Quality

| <u>Qualification</u> | <u>Number of Teachers (N<sub>q</sub>) x</u> | <u>Qualification Wt. (Q) =</u> | <u>Value</u> |
|----------------------|---|--------------------------------|--------------|
| Bachelor             | 12 (N <sub>q1</sub> )                       | 2 (Q <sub>1</sub> )            | 24           |
| Master               | 20 (N <sub>q2</sub> )                       | 3 (Q <sub>2</sub> )            | 60           |
| Specialist           | 2 (N <sub>q3</sub> )                        | 4 (Q <sub>3</sub> )            | 8            |
| Doctorate            | 1 (N <sub>q4</sub> )                        | 2 (Q <sub>4</sub> )            | 2            |
| Other                | 2 (N <sub>q5</sub> )                        | 1 (Q <sub>5</sub> )            | 2            |

  

| <u>Experience (E)</u>         | <u>Number of Teachers (N<sub>e</sub>) x</u> | <u>Experience Wt (E) =</u> | <u>Value</u> |
|-------------------------------|---|----------------------------|--------------|
| < 1 year (E <sub>1</sub> )    | 1 (N <sub>e1</sub> )                        | 1 (E <sub>1</sub> )        | 1            |
| 1-10 years (E <sub>2</sub> )  | 6 (N <sub>e2</sub> )                        | 2 (E <sub>2</sub> )        | 12           |
| 11-20 years (E <sub>3</sub> ) | 12 (N <sub>e3</sub> )                       | 3 (E <sub>3</sub> )        | 36           |
| 21-30 years (E <sub>4</sub> ) | 12 (N <sub>e4</sub> )                       | 4 (E <sub>4</sub> )        | 48           |
| >30 years (E <sub>5</sub> )   | 7 (N <sub>e5</sub> )                        | 5 (E <sub>5</sub> )        | 35           |

  

|                    |  |  |            |
|--------------------|--|--|------------|
| <b>Total Value</b> |  |  | <b>228</b> |
|--------------------|--|--|------------|

If total number of enrolled students for the school year = 627, the TEACHQLT index =  $228/627 \times 100 = 36.36$ . The transformation is based on the Training & Experience (T & E) Scale for Teachers, Georgia Department of Education.