STUDENT WORK SECTION

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The paper in this section describes work undertaken by a student at the Academy for the Advancement of Science and Technology, Bergen County Academies, Hackensack, New Jersey. This work was presented in the poster session of the 2004 Annual Meeting of the National Council of Teachers of Mathematics held in Philadelphia, Pennsylvania.

ANALYSIS OF SOCIO-ECONOMIC FACTORS IN CORRELATION TO STANDARDIZED EDUCATIONAL TEST SCORES

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Abstract

This paper describes the analysis of socio-economic factors in correlation to standardized educational test scores. The scores used were from the Elementary School Proficiency Assessment exam distributed to fourth graders in New Jersey during the years 1999, 2001- 2003 [1-4]. The socio-economic factors are from the 2000 United States Census [5]. Simple regression and other statistical equations were used to compare the data from both sources with *Microsoft Excel* as a programming tool to perform the analysis.

Introduction

The Greek philosopher Pythagoras believed that numbers were the basis for understanding our existence, or certain aspects of our existence. He suggested that mathematics told the story of life and that through comprehension of their connection, we could better understand ourselves and our lifestyles. Aristotle frequently wrote about the Pythagoreans. In his *Metaphysics*, he wrote, "...the Pythagoreans, who were the first to take up mathematics, not only advanced this study, but also having been brought up in it they thought its principles were the principles of all things." [6]

The superintendent of the Clifton, N.J. school district stated to *The Record* of Hackensack, N.J. in 2000 that state test results correlated to socio-economic status. He said that. "...it's socio-economic conditions that determine achievement." [7]

A statistical analysis will be performed in an attempt to correlate certain socio-economic factors and the standardized test scores of New Jersey students. On a broader scale, the analysis will also try to prove a relationship between the Pythagorean theory of mathematics and the superintendent's comment.

Bergen County

Bergen County is located in the northeastern corner of New Jersey and is one of the most affluent counties in the state. However, the economic range of the population varies from poverty to affluence. The county also has a relatively high percentage of senior citizens. Racially diverse, there is a concentration of African-Americans in several communities while the Hispanic population continues to grow throughout the county. However, the most significant recent demographic growth is in the Asian population. Even in towns that have not drastically changed, a general pattern of diversity has emerged. Since Bergen County lies in a premier location relative to New York City, there are many commuters. A socio-economic group pertains to the state's classification of communities based on the overall financial status of its residents. The Department of Education breaks New Jersey into eight groups. Bergen County does not contain any district at the lowest economic level, group one. There are five districts in socio-economic group two, reflecting the lower-middle-class population. Fifty-eight communities fall in groups three through seven. Finally, the five most affluent districts are represented in socio-economic group eight. Tables 4 and 5 vividly demonstrate that more students score in the partially proficient category in less affluent towns. Conversely, more prosperous towns have a higher percentage of students achieving the advanced proficiency distinction in math and language arts. This economically complex county serves well as a representative statistical model comprising a general crossection of the population [5,8].

Elementary School Proficiency Assessment (ESPA)

The New Jersey Department of Education (NJDOE) in 1996 decided to implement a statewide assessment test for fourth, eighth, and eleventh grades. After an initial practice run in 1998, all of the students in fourth and eighth grades were tested in 1999. The Elementary School

Proficiency Assessment (ESPA) and Grade Eight Proficiency Assessment (GEPA) have been given in the spring for the past six years. Results are published the following winter in regional newspapers.

Each elementary school can be identified with a particular local district. Therefore, the ESPA is ideal for comparison of each community's ESPA test scores and census figures. More problems arise for comparison at the eighth grade level because a few communities send students to one regional middle school.

Sample

Bergen County has seventy towns, sixty-eight of which have schools. Two communities have small school-age populations where the students attend one of the surrounding district's public schools. The total of all public schools is 150. If a town had more than one school, then the test scores were averaged. The sample size is universal for the 1999, 2002, and 2003 tests. This means that no school was excluded in the sample. No ESPA results were posted for two schools in 2001, reducing the sample (n=67). The cumulative total is 99.7% of all test scores for the four years which were reviewed for the study.

The ESPA results were broken down by the NJDOE into three categories—partially proficient, proficient, and advanced proficient—for each year. With the exception of 2000, the test scores could be categorized easily from published sources like newspapers. For the purpose of this study, it was deemed sufficient to use the statistics for the other four years, 1999, 2001-2003.

The *2000* Census data offered three intriguing possibilities for study: the Median Family Income (w/minors), the Single Female Median Income (w/minors), and the percentage of Public Assistance Families. The test scores from the ESPA for Partial and Advanced Proficiency in Language Arts and Mathematics were compared with these three Census factors.

Initial Project

The initial project in Fall 2003 focused on correlating 2002 fourth grade, Advanced Proficiency test results with the three socio-economic factors. A strong correlation between economic and educational factors was established for Median Family Income (w/minors), a moderate one for Public Assistance Families, and a weak one for Single Female Median Income (w/minors).

Publication of the 2003 statistics in March 2004 presented an opportunity to do a longitudinal study. My student exhibit at the 2004 National Council of Teachers of Mathematics (NCTM) conference in Philadelphia compared the 2002 and 2003 Advanced Proficiency scores with Median Family Income (w/minors) and Single Female Median Income (w/minors). The public assistance factor had to be dropped from the display because of space limitations.

Longitudinal Study

Reviewing earlier ESPA scores raised exciting possibilities, since the longitudinal study could now encompass four years of data. Comparisons could be made for both advanced and partially proficient test results county-wide. From an initial study of ten sets of data which were limited to advanced proficiency, the study expanded to forty-eight sets of data over a four-year period.

Limitations

The universality of the sample is limited to public schools only. No parochial or private grammar schools are included. While there are more than seventy non-public schools in the county, many do not offer programs past kindergarten [9]. Local school districts frequently offer only half-day kindergarten sessions, resulting in a private market for this grade level only. Tables from NJDOE group together all students for the K-6 level [9]. Finding the mean of the seventh and eighth grade totals renders a reasonable estimate of approximately 1,700 students in fourth grade in non-public schools.

Table 1
Statistics from the New Jersey Department of Education, Tables 8, 55-57.

	7^{th} & 8^{th} Grade Total	New Non-Public (7 & 8) Average	Public (4^{th} Grade)	Total	Non-Public Percentage
1998	3145	1573	9165	10,738	14.65
1999	3180	1590	9480	11,070	14.36
2000	3170	1585	9499	11,084	14.30
2001	3340	1670	9514	11,184	14.93
2002	3386	1693	9775	11,468	14.76

The ratio of non-public to public school students is 1:6, rendering a significant 14% omission in the published data. Not all fourth grade students take the State standardized exam, limiting any broad conclusions about test results.

The cluster of religious-affiliated and private schools lowers test scores in a few districts. Selective private elementary as well as parochial schools attract students from public schools. Certain towns have a significant disparity between rich and poor. Children from less affluent families are more likely to attend the local public school. The student body of a public school may not reflect the overall wealthier socio-economic demographics of the community. If the U.S. Census Bureau issued quartile as well as median figures, this statistical variation could be significantly reduced.

The initial ESPA exam in 1999—particularly the language arts section—set off a controversy. "Many students told teachers that they did not understand the test directions and that nine- and ten-year-olds were unable to sit through test sections that were up to 100 minutes long." This quote from *The Record* of September 22, 1999 indicates why statistics from that year are undermined [10]. However, the first test—which by its nature was experimental—established a baseline of comparison for subsequent years.

The tables for 2001-2002 show generally higher correlations than either 1999 or 2003. On February 6, 2003, just two months before the test was to be taken, *The Record* reported that the ESPA would be revised [3]. The decreased correlation for 2003, except for Language Arts Partial Proficiency, suggests that the revisions to the test were insufficient. The validity of the current test should be seriously questioned.

Local conditions, possibly outside the control of school administration, may cause poor test results. These conditions include, but are not limited to: extended illness or disability of a teacher, teacher experience, student mobility (those students moving in and out of districts), teachers' salaries, and teachers' credentials.

Results

The pattern shows that the more affluent districts performed better in mathematics than the poorer ones. The Public Assistance category also reasonably measures the correlations for both Mathematics and Language Arts. Wealthier communities have lower rates of public assistance than poorer communities. The Single Female Median Income (with minors) category demonstrated the weakest correlations. Often there was barely a distinguishable pattern in the statistics.

Table 2
Percentage Correlation for the Three Categories in Each Year

	1999	2001	2002	2003
Math ap				
MFI	33.5937106	65.4197921	68.5296483	41.8713549
SFMI	7.4224345	17.335806	13.3141005	0.6233027
PA	32.827369	42.2387986	45.7409146	24.7365712
LA ap				
MFI	19.0924754	34.9736627	46.7679488	23.7278247
SFMI	2.7676747	1.8173629	18.2685117	4.2912426
PA	5.2810053	17.6604093	26.5775787	17.9233817
Math pp				
MFI	51.8662495	40.4296536	49.8653682	42.9841152
SFMI	53.7344309	15.3653297	14.7519481	11.2054276
PA	54.8996631	52.3734452	48.0691536	39.5383983
LA pp				

MFI	36.2603738	28.5550664	25.0434274	52.5358363
SFMI	10.3520871	10.688455	14.2135371	14.9974106
PA	25.9476697	48.2577186	33.3608074	39.7659077

ap = advanced proficiency	SFMI = Single Female Median Income (w/minors)
pp = partial proficiency	LA = Language Arts
MFI = Median Family Income (w/minors)	PA = Public Assistance

Table 3
Correlation Between Economic Factors and Standardized Test Scores, Based on Four-Year Analysis

Strongest Correlations		
1.	Mathematics Advanced Proficiency/Median Family Income	52.35%
2.	Mathematics Partial Proficiency/Public Assistance	48.72%
3.	Mathematics Partial Proficiency/Median Family Income	46.29%
4.	Language Arts Partial Proficiency/ Public Assistance	36.83%
Moderate Correlations		
5.	Mathematics Advanced Proficiency/Public Assistance	36.39%
6.	Language Arts Partial Proficiency/ Median Family Income	35.60%
7.	Language Arts Advanced Proficiency/Median Family Income	31.14%
8.	Mathematics Partial Proficiency/Single Female Median Income	23.76%
Weakest Correlations		
9.	Language Arts Advanced Proficiency/Public Assistance	16.86%
10.	Language Arts Partial Proficiency/Single Female Median Income	12.56%
11.	Mathematics Advanced Proficiency/Single Female Median Income	9.67%
12.	Language Arts Advanced Proficiency/Single Female Median Income	6.97%

The Median Family Income (w/minors) showed the strongest correlations, followed closely by Public Assistance Families. No connection could readily be demonstrated with the Single Female Median Income (w/minors). Math scores correlated better than language arts for the three categories reviewed.

A distinguishable comparable pattern of socio-economic group factors and standardized test score achievement levels becomes apparent in Tables 4 and 5.

Table Four
Median Mathematics Advanced Proficiency scores of the Socio-Economic Groups 2-8 for the Years 1999, 2001-2003

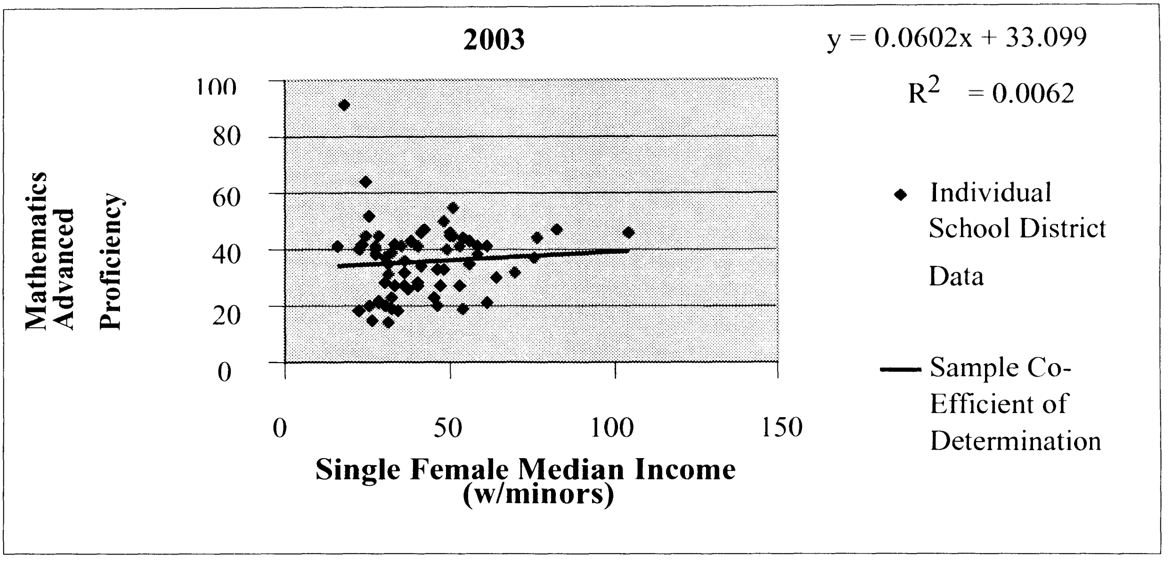
Mathematics				
Advanced Proficiency (Median Scores)				
Socio-Economic Group	1999	2001	2002	2003
Two	8	13	22	20
Three	16	25	26	35
Four	14	27	31	27
Five	24	30	37	27
Six	21	38	42	41
Seven	32	41	53	43
Eight	33	63	64	41
Partial Proficiency (Median Scores)				
Socio-Economic Group	1999	2001	2002	2003
Two	40	33	26	40
Three	31	21	22	26
Four	27	19	15	22
Five	18	16	15	27
Six	16	8	12	20
Seven	10	7	6	13
Eight	13	3	4	11

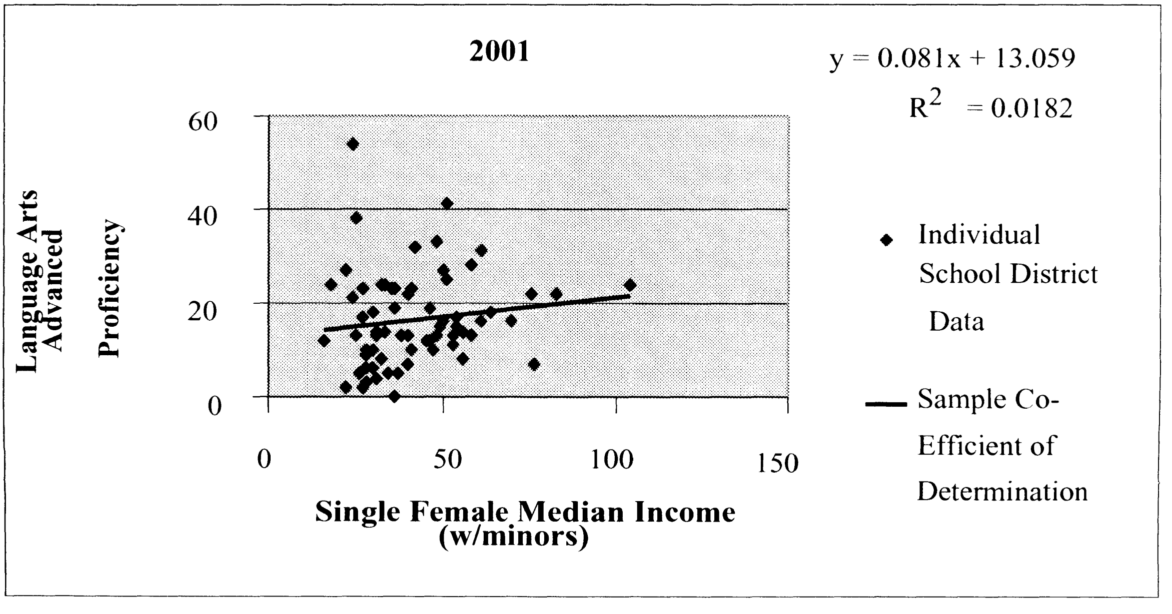
Table Five
Median Language Arts Advanced Proficiency Scores of the Socio-Economic Groups 2-8 for the Years 1999, 2001-2003

Language Arts				
Advanced Proficiency (Median Scores)				
Socio-Economic Group	1999	2001	2002	2003
Two	0	5	5	2
Three	0	6	5	2
Four	0	8	5	4
Five	0	13	7	4
Six	1	14	7	6
Seven	1	23	15	8
Eight	1	23	23	10
Partial Proficiency (Median Scores)				
Socio-Economic Group	1999	2001	2002	2003
Two	62	9	8	26
Three	56	7	8	19
Four	51	6	7	13
Five	32	4	8	13
Six	33	2	4	8
Seven	27	1	2	6
Eight	26	0	1	4

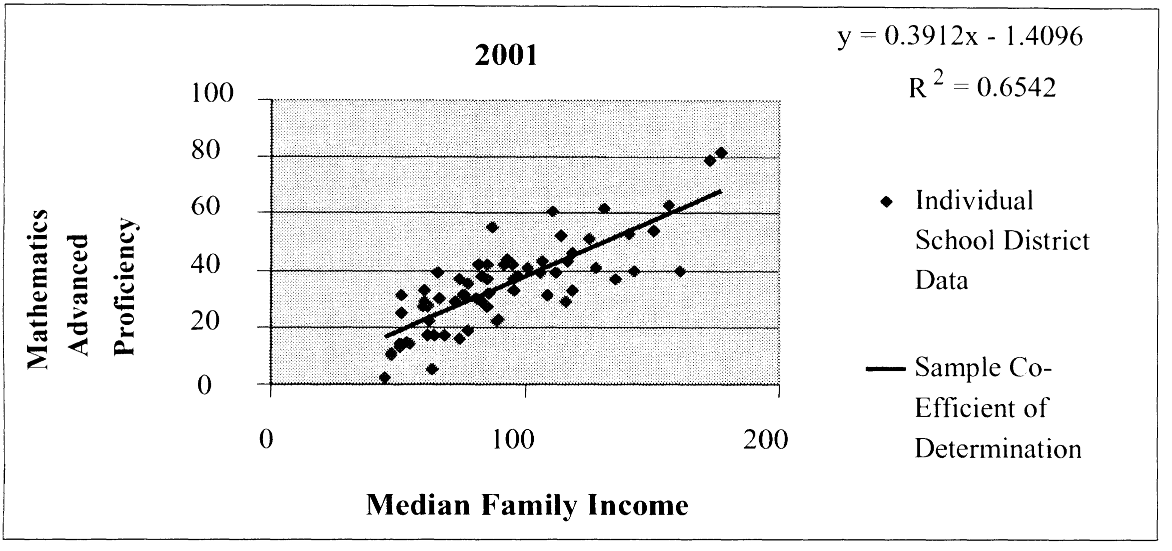
Graphs

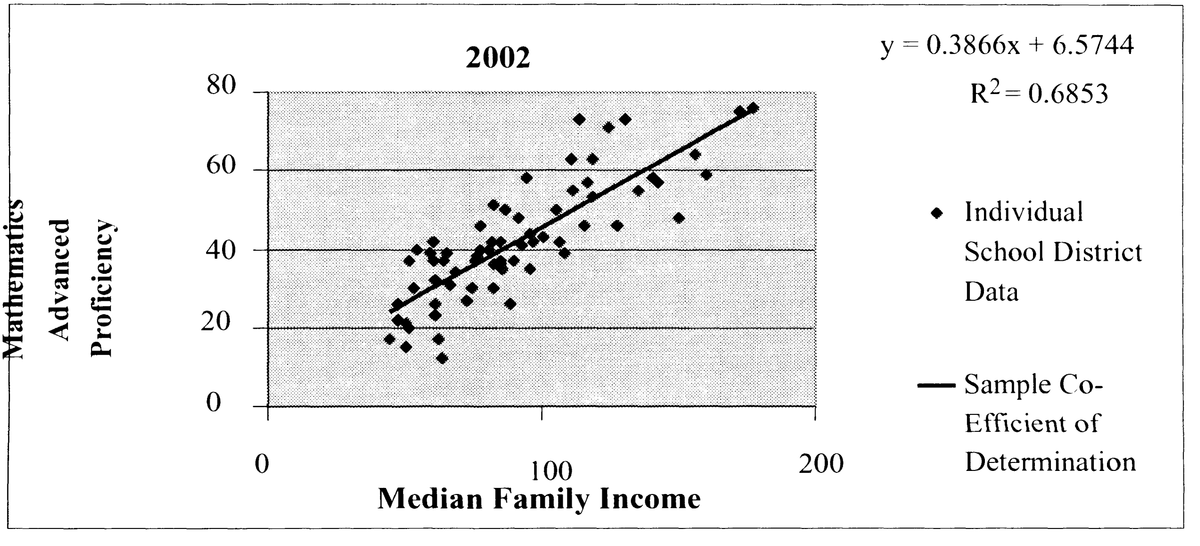
These two graphs have the least correlation of the sample.





These two graphs have the greatest correlation of the sample.





Technology

A *Microsoft Excel* spreadsheet was used to plot the data and graph it. The slope of the linear equation and r^2 were calculated—by the spreadsheet—from the trendline with the graph of the y-intercept added to ensure that my calculations were correct. By comparing the slopes and r^2, it was determined that the results were accurate.

Reform

If all of the students were tested universally, then the scores could be assigned to the town of residence, not just the school. Should a student be attending a private or parochial school located outside of their community, then the scores would be included with their local hometown school district. Simultaneous testing of all students in all schools would serve as a universal sample. Skewing of statistics would be minimized and accuracy thus improved. The disparity among test scores would be reduced, and the standard error of estimate narrowed, allowing for the towns' individual test scores to become closer to the regression line. Correlations between socio-economic factors and standardized test scores would improve because the results would truly reflect an accurate cross section of the student population.

Conclusion

From a plethora of numbers, assumptions can be proven and discarded. Indeed, the superintendent was right in his belief about socio-economic factors determining achievement. However, there are limitations even on the superintendent's statement. His response to the reporter's question was somewhat oversimplified, too broad to draw specific conclusions. Yet once the surface has been penetrated, there are imperative conclusions that can be drawn about the state of our educational system. For instance, the results reveal that there is a specific trend in correlation between Median Family Income (w/minors) and Public Assistance Families with educational test scores; but, no strong correlation exists with Single Female Median Income (w/minors) compared to educational test scores. Other socio-economic factors exist, but have no apparent connection to educational test scores. For example, the Census lists the amount of people on Social Security and Supplemental Security Income. Obviously, numbers relating to seniors would have no significant effect on the test scores of nine- and ten-year-olds. Broad population groups may have only a tangential sociological connection to children attending schools. Therefore, an analysis of results can challenge, impact, and stimulate discussion of public educational policy.

But is Pythagoras' theory valid? Can mathematics tell the story of our life or of our existence? Although my study pertained to only a small aspect of life, it simply shows how it is possible to use mathematics to draw broad conclusions about our daily lives. This opens the realm of possibility to examine our role in society, improve on our lives, our education, and eventually, our existence—by means of mathematics. ■

References

[1] "Fourth Grade Test Scores," *The Record*, Hackensack, NJ, Dec. 1999.

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[3] B. Kladko, "Fourth Grade Test Scores," *The Record*, Hackensack, NJ, Feb. 2003.

[4] "North Jersey School Report Cards, Fourth Grade," *The Record*, Hackensack, NJ, Mar. 2004.

[5] U.S. Census Bureau website, Internet: http://factfinder.census.gov/

[6] Aristotle, *Introduction to Aristotle*, Richard McKeon (ed.), Modern Library, New York, NY, 1947.

[7] J. Chadwick, "Test Scores Run Gamut in Clifton, But Why?—Schools Hope to Stop Slide in Poor Areas," *The Record*, Hackensack, NJ, Jan. 2000.

[8] P.H. Johnson, "Growing Diversity in North Jersey—Census Estimates Show Asian Boom," *The Record*, Hackensack, NJ, Aug. 2000.

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[10] J. Rimback and D. Glovin, "Pupils Do Not Fare Well on New State Exams," *The Record*, Hackensack, NJ, Sept. 1999.

[11] *Principles and Standards for School Mathematics*, National Council of Teachers of Mathematics, Reston, VA, 2000.

[12] R.I. Levin, *Statistics for Management*, Prentice-Hall, Englewood Cliffs, NJ, 1984.

Appendix A
Standard Error of Estimate

"A measure of the reliability of the estimating equation, indicating the variability of the observed points around the regression line; i.e., the extent to which observed values differ from their predicted values on the regression line." [12]

Se	1999	2001	2002	2003	Average
Math ap					
MFI	11.13304299	9.313645631	8.516066197	9.782808821	9.68639091
SFMI	13.14504743	14.40007081	14.13391451	12.79118399	13.61755419
PA	11.19709747	12.03715959	11.18212814	11.13167367	11.38701472
LA ap					
MFI	1.327543098	8.132186481	6.093045575	4.653819378	5.051648633
SFMI	1.455323386	9.992635111	7.549923127	5.213174907	6.052764133
PA	1.436391123	9.150967956	7.155865632	4.827654533	5.642719811
Math pp					
MFI	9.443039248	10.05675267	6.39208257	8.205644967	8.524379864
SFMI	9.292621189	11.9871754	8.335193625	10.24018962	9.963794959
PA	9.140644879	8.992227581	6.505582095	8.449959204	8.27210344
LA pp					
MFI	13.31459319	5.136625106	4.602544462	5.378954511	7.108179317
SFMI	15.79040384	5.743094373	4.923823913	7.198318067	8.413910048
PA	14.35134187	4.371343538	4.339682889	6.059490929	7.280464807

Appendix B

Data Analysis and Probability

Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them; select and use appropriate statistical methods to analyze data; develop and evaluate inferences and predications that are based on data [11].

- for bivariate measurement data, be able to display a scatterplot, describe its shape, and determine regression coefficients, regression equations, and correlation coefficients using technological tools
- identify trends in bivariate data and find functions that model the data or transform the data so that they can be modeled.

Appendix C [12]

$$Y = a + bX$$

This standard linear equation is used to determine the regression trendline. *Y* is the dependent variable, the educational standardized test scores. *X* is the independent variable, which represents the economic data that is fixed. The variable *n* represents the number of data points. The slope of the best fitting estimation line (*b*) is calculated through the following equation:

$$b = \frac{\sum XY - n\overline{X}\overline{Y}}{\sum X^2 - n\overline{X}^2}$$

The new variables represent the mean of the values of the economic data $\overline{X}$ and the mean of the values of the standardized test scores $\overline{Y}$. The number of data points is represented by the variable *n*. To determine the y-intercept (*a*) in the linear equation, the following equation must be used with all of the former values kept in mind:

$$\alpha = \overline{Y} - b\overline{X}$$

To determine the standard error of estimate, the following equation was used with a as the y-intercept, b as the slope of the line, X as the value of the independent variable, Y as the value of the dependent variable and n as the number of data points:

$$S_e = \sqrt{\left(\sum Y^2 - a\sum Y - b\sum XY\right)/(n-2)}$$

To determine the correlation of the data or the sample coefficient of determination (r^2), the following equation was used with a as the y-intercept, b as the slope of the best fitting line, n as the number of data points, X as the value of the independent variable, Y as the value of the dependent variable, and Y-bar as the mean of the values of the dependent variable:

$$r^2 = \frac{a\sum Y + b\sum XY - n\overline{Y}^2}{a\sum Y^2 - n\overline{Y}^2}$$