The University of Chicago
Department of Statistics

TECHNICAL REPORT SERIES

Who is left behind, and where?

Statistical Analysis of Children's Performances
and Their Demographic Characteristics

Chinglan Huang, Mei Wang

TECHNICAL REPORT NO. 575

Departments of Statistics
The University of Chicago
Chicago, Illinois 60637

December, 2006

Who is left behind, and where?

Statistical Analysis of Children's Performances and Their Demographic Characteristics

Chinglan Huang, Mei Wang

December, 2006

Abstract

Sociologists and educators strive to discover possible relationships or associations present among children's performances and their demographic characteristics. By discovering patterns and trends, educators can develop different strategies and recommendations to improve the effectiveness, efficiency, and quality of current education systems. This study contains exam scores of 92 inner city public school children and their demographic characteristics. Through model building and other statistical techniques, researchers wish to explore possible associations among children's demographic characteristics and performances in areas like language arts, visual arts, mathematics, sciences, and performing arts. Interestingly, grade, ethnicity and number of repetition of an exam are indeed significant covariates in terms of predicting children's performances. Furthermore, there seems to be a relatively low correlation present among different performances within a child. This suggests that learning profile for each child may be highly individual. Unlike usual, the results indicate that ethnicity and socio-economic status are not the only primary factors which may affect children's performances in various areas.

* This Technical Report is closed based on the first author's Statistics Master's Paper completed at the University of Chicago with the second author as the advisor.

I. Introduction

Does ethnicity play a significant role in predicting children's performances in certain areas? How about number of repetition to a certain type of exam? Is there any relationship present among children's demographic characteristics and performances in various areas? In this study, with 92 children, their scores and demographic characteristics included, researchers wish to discover patterns which educators and sociologists can utilize toward education development. Although evaluations are based on 19 kinds of activities which are classified into 5 different areas, such as Language Arts, Visual Arts, Mathematics, Sciences, and Performing Arts, analyses are performed based on data organized in two different types - one accounts for averages in 5 main areas and one accounts for all observations in 5 areas. However, some of the 92 children do not have complete records of performances in every area. Since most of the missing values are in the response variable- score, complete case analysis seems adequate and appropriate for treating the missing values. Demographic characteristics include grade, gender, ethnicity, socio-economic status, number of full-time adults, primary language, and number of repetition of an exam. While score, ranging from 1 to 10 is treated as response, the demographic characteristics are all categorical variables. With these information given, one wishes to discover any interesting associations present among children's performances and their demographic characteristics.

II. Dataset and Variables

In the original dataset, for each of the 92 children, demographic characteristics and scores in all 19 exams are expected. The variables can be decomposed into two parts, "responses" and "covariates". In "responses", 19x2=38 scores which can be classified into 5 areas are expected per child. (The reason that number of score per child is doubled is due to repeated measurement of exams at the second time.) Interestingly, some of the children do not have scores in all 19 exams and not all of them have repeated all exams. In terms of demographic variables, grade, gender, ethnicity, socio-economic status, number of full-time adults, primary language, and number of repetition of an exam are included. Grade, as a categorical variable, can be classified into two groups, 1-

PreKindergartender and 2-Kindergartender. Gender, categorical, has levels of 1-female and 2-male. Ethnicity, as a category, contains 7 levels, 1-Latino, 2-African-American, 3-Caucasian, 4-Asian/Pacific Islander, 5-Native American (none of the children fall in this category), 6-Bi/Mixed-race and 7-Middle Eastern. Socio-Economic Status contains 3 levels, 1-low/very low, 2-middle, and 3- upper-middle/high. Number of full-time adults can be classifies into 3 levels, 1-1 adults, 2-2 adults, 3- 3 or more adults. Primary language can be classified into 3 levels, 1-English, 2-Spanish, and 3-Other. Lastly, a special column- number of repetition of an exam is created to correspond with the responses. Number of repetition of an exam contains two levels, 1-first time, 2-second time and this corresponds with all of the 19x2=38 scores per child. Upon different needs, two data formats are created. One is the "mean-score" dataset and the other is "score" dataset. In "mean-score" dataset, after complete case analysis, each student has only 5 responses- average of all Language Arts scores, average of all Visual Arts scores, average of all Mathematics scores, average of all Sciences scores, and average of all Performing Arts scores. On the other hand, the "score" dataset contains ALL observations after removal of non-response. No scores are combined or averaged in this dataset. With "mean-score" dataset, single-response regressions, mean score comparisons, different correlations and correlations with different groupings are built. With "score" dataset, a mixed-effect model is built to explain the relationship between scores and other demographic components.

III. Analysis and Model

A. Various Mean Scores Displayed by Different Demographic Components

To discover whether performances in different areas are associated with demographic variables, the mean scores of all activities are calculated. Regardless of detailed activities, scores are classified by main activities and averaged for the sake of simplicity. Mean scores of all children in areas like Language Arts, Visual Arts, Mathematics, Sciences, and Performing Arts, displayed in red, black, green, blue and light blue respectively in Figures A-1 through A-4 are assessed while different demographic components, such as Socio-Economic Status, Ethnicity, School ID, and Primary Languages are considered. In

the following graphs, Figures A-1 through A-4, mean scores of various activities are compared by levels of different demographic variables.

A-1. Socio-Economic Status

In Figure A-1, as levels of Socio-Economic Status move upward, various types of mean scores tend to increase as well with an exception of light blue- Performing Arts: there is a sudden drop in the mean score of Performing Arts from socio-economic status two to three. Figure A-1 suggests that children's socio-economic status solely may play a significant role in terms of their performances in various subjects.

A-2. Ethnicity

In Figure A-2, one can see that comparing among levels of ethnicity, Asian/Pacific Islander tends to score the highest in areas such as Mathematics, Visual Arts, Language Arts, and Sciences. While performances in various areas tend to be parallel between two ethnicity groups, Asian/Pacific Islander and Caucasian, there are interactions present among certain areas and other ethnicity groups. This suggests that there are certain areas in which some ethnicity groups perform relatively better than others. There is no generalization that any ethnicity group performs absolutely better in all areas. Even though ethnicity group 4 and 3, Asian/Pacific Islander and Caucasian tend to perform well in most areas, they score low in performing arts relatively to other ethnicity groups. While ethnicity group 2, African-Americans show exceptional performance in Performing Arts, ethnicity group 7, children with Middle Eastern heritage appear to perform well in Visual Arts and Language Arts. Relatively to all other ethnicity groups, Bi/Mixed-race and Latino children appear to have low means in most areas, such as Mathematics, Visual Arts, and Language Arts.

A-3. Primary Language

From Figure A-3, one can see that comparing among levels of primary language, children with primary language 2, Spanish tend to have relatively low performances in all areas other than performing arts. Furthermore, performances of children with primary language 2, Spanish, in the area of language arts seem to deviate the most from those with other primary languages. Interestingly, although children with primary languages 1 and 3,

English and other tend to have relatively high performances in most areas, they do not seem to be outstanding in the area of Performing Arts. Again, such an illustration suggests that there is no generalization one can establish regarding the associations present among children's primary languages and relative performances in various areas. No particular type of children can be classified or entitled as "excellent" or "poor" in terms of their general performances. Children who differ in primary languages may perform well or poorly in different areas, but there is no absolute general pattern one can conclude about them. Children's performances in different areas indeed vary upon their primary languages.

A-4. School ID and Grade

In Figure A-4, children's performances in different areas are displayed by school id. Notice that the children in schools 1 and 2 (kindergarteners) are older than the children in schools 3 and 4 (pre-kindergarteners), thus all subsequent comparisons or analysis should be conditioned on this fact. Not surprisingly, older children performed better on average in all areas. School 3 seems to have relatively low performances in most areas except Performing Arts. Although school 1 tends to have relatively high performances in most areas, children's scores do not seem to be remarkable in the area of performing arts. In some areas, performances of children can be ranked as: school 1 > school 2 > school 4 > school 3 (notice the effect of age difference). However, in the area of Performing Arts, children in school 3 seem to perform relatively better or tend to deviate less from other schools. Again, similar to other demographic aspects, socio-economic status, ethnicity, and primary language, there is no generalization one can conclude regarding children's performances in different schools. Although mean scores of children in different areas are displayed in graphs by different demographic aspects, one can conclude that there is no generalization about performances of children given their demographic information.

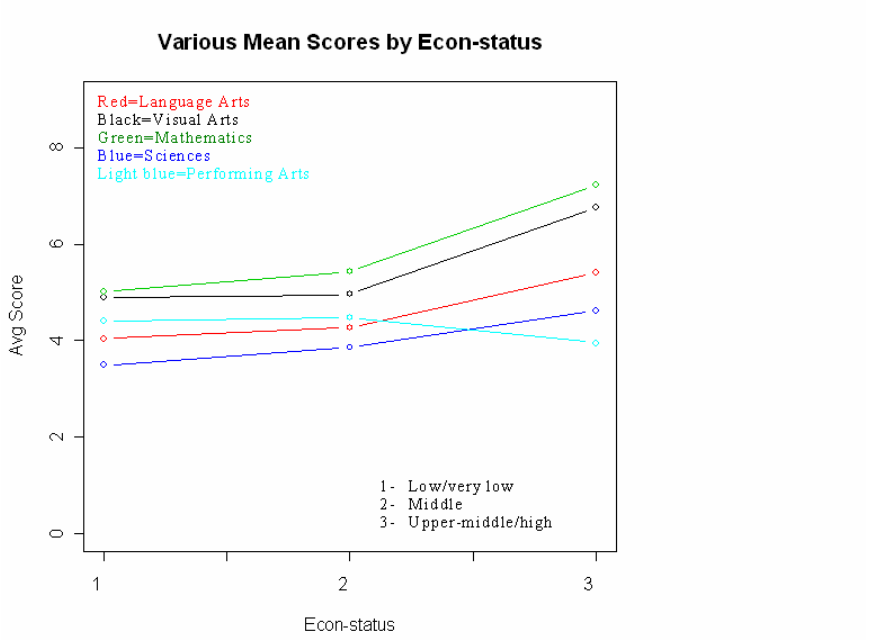

Figure A-1: Various Mean Scores by Socio-Economic Status

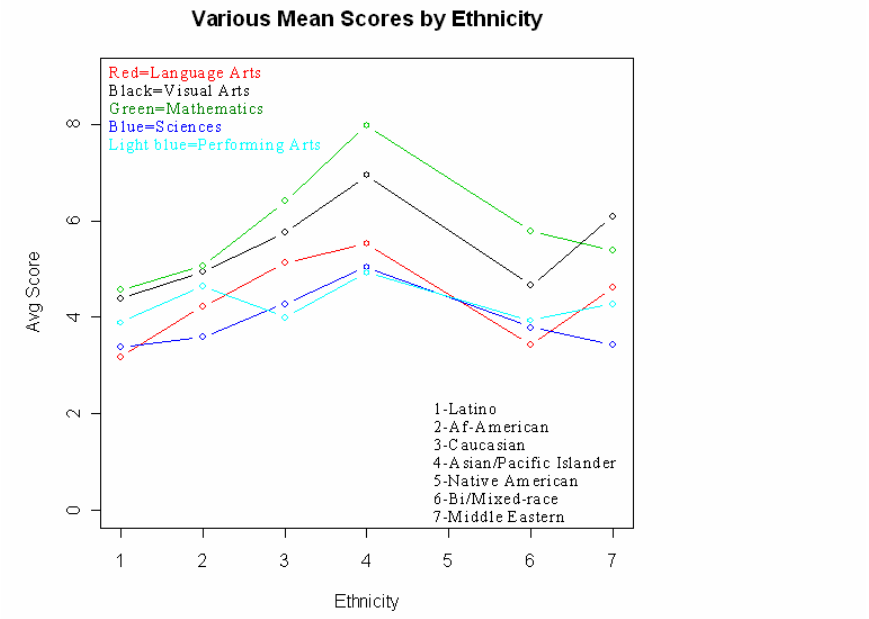

Figure A-2: Various Mean Scores by Ethnicity

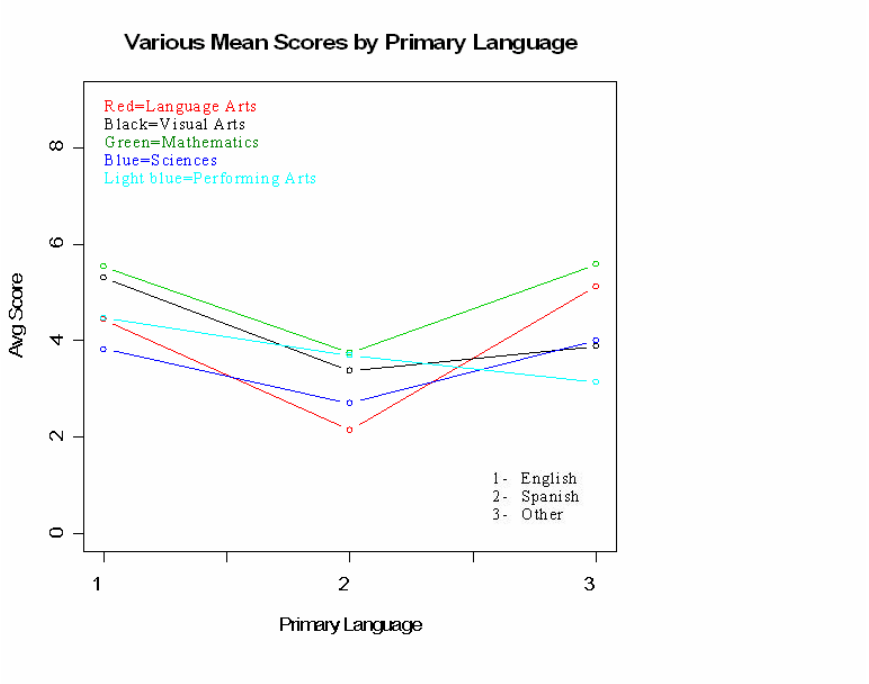

Figure A-3: Various Mean Scores by Primary Language

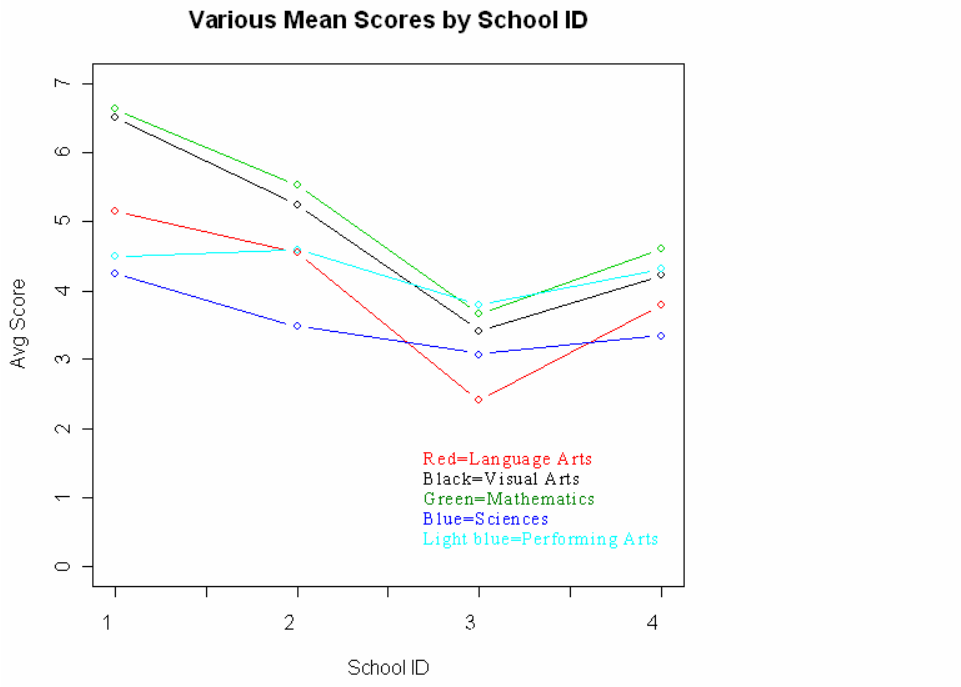

Figure A-4: Various Mean Scores by School ID and Grade (Kindergartener: schools 1 and 2, Preschooler: school 3 and 4)

B. Nature of Data, Missing Values, and Complete Case Analysis

The data contains most missing values in the response variable. Since no auxiliary data is given which may be used to evaluate possible performances in different areas--to fill in the response, score, the analyst believes that complete case analysis may be appropriate and valid in this case. With 92 children, 3497 observations included in the original dataset, after dropping all observations where any particular variable is missing, 84 children, 2516 observations are left in the new dataset, to which further analyses would be applied.

By applying cluster analysis on missing values, Figure B-1, one can see that around 20% of the scores are missing. Relatively to the number of missing values in response, a very small portion of the data consists of missing values in other covariates, such as thnicity, economic status, primary language and part time/full time adults. By eliminating all observations where any particular variable is missing, the distributions of observations are not significantly different from those before eliminations. In detail, Figure B-2, B-3, and B-4, distributions of observations displayed by various demographic aspects- socio-economic status, ethnicity, and primary language before and after missing-value elimination illustrate that there are no significant differences between distributions before and after elimination. Figure B-2, B-3, and B-4 confirm that a complete case analysis is adequate and valid for this data.

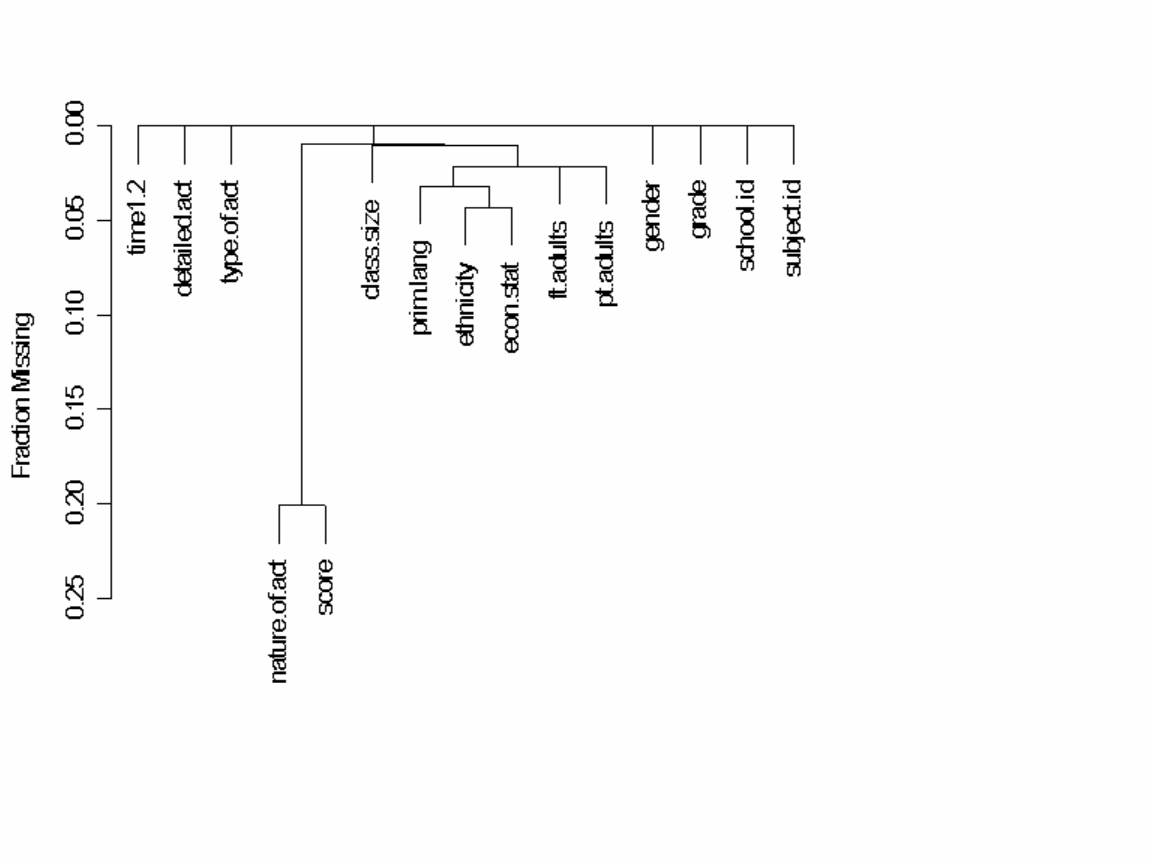

Figure B-1: Cluster Analysis on Missing Values

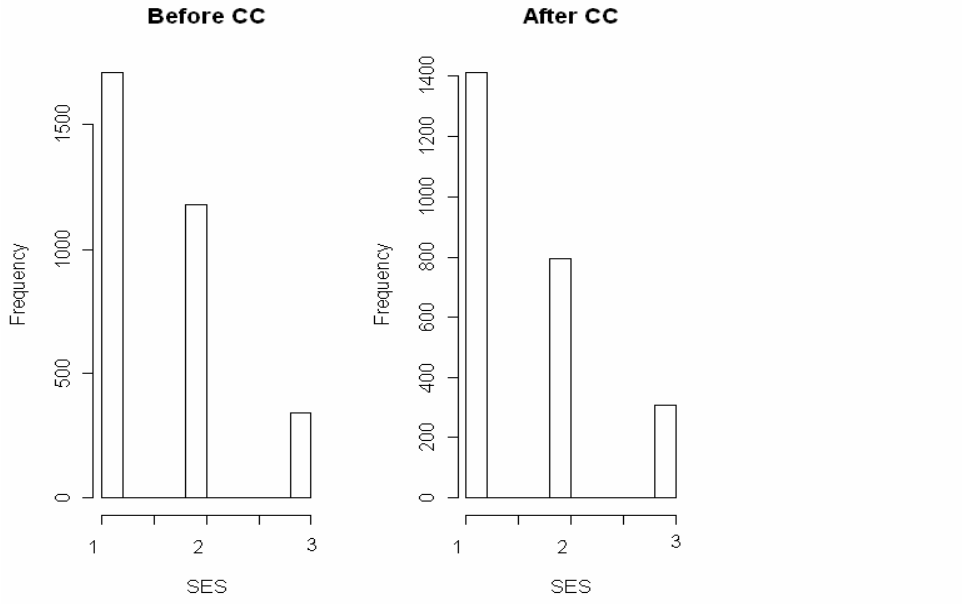

Figure B-2: Distribution of Socio-Economic Status Before and After Removing Observations with Missing Values

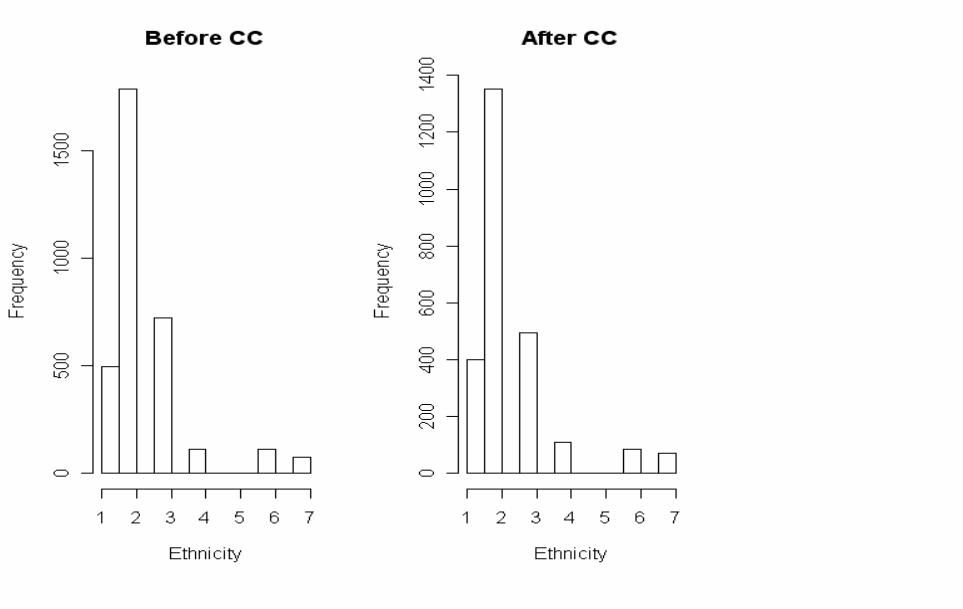

Figure B-3: Distribution of Ethnicity Before and After Removing Observations with Missing Values

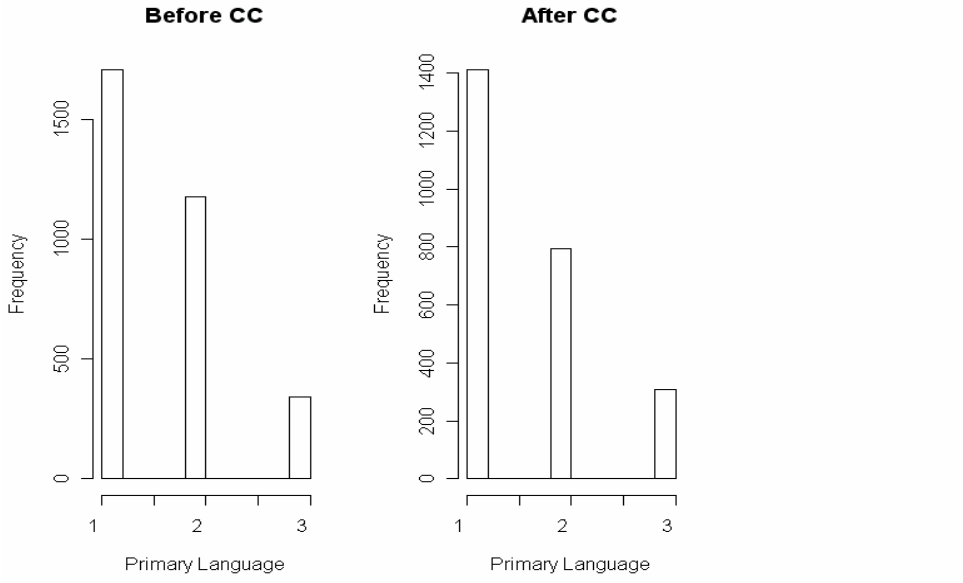

Figure B-4: Distribution of Primary Language Before and After Removing Observations with Missing Values

C. Correlations among Various Mean Scores

In order to detect possible patterns present among performances in various areas, correlation matrices listed in the following tables are constructed. The tables of correlations can function as preliminary summaries which help to assess possible associations present among different types of scores. In addition, correlations of various mean scores grouped by different levels of demographic variables are also established and hopefully to serve as preliminary summaries for possible pattern assessment.

In Table C-1, one can see the overall correlations among different types of mean scores based on the complete case data. Among the ten correlations displayed, Language Arts and Visual Arts; Language Arts and Mathematics; and Visual Arts and Mathematics seem to have relatively higher correlations than other pairs. Having correlations above .70, these three pairs are positively correlated. These correlations indeed suggest that children tend to have similar performances in these areas. Furthermore, performances of children in these areas tend to move or shift in the same direction. For example, given children who have remarkable performances in Language Arts, the overall correlations suggest that they would have relatively remarkable performances in Mathematics and Visual Arts as well. Performances in these three areas are positively correlated. In conclusion, children's performances shift and move toward the same direction in areas of Language Arts, Mathematics, and Visual Arts.

	Language Arts	**Visual Arts**	**Mathematics**	**Sciences**	**Performing Arts**
Language Arts	1				
Visual Arts	**0.759353**	1			
Mathematics	**0.733847**	**0.739562**	1		
Sciences	0.533466	0.517955	0.58812	1	
Performing Arts	0.407153	0.430408	0.298632	0.158006	1

Table C-1: Correlations of Various Mean Scores

After seeing the overall correlations among various mean scores, patterns among scores grouped by different demographic variables can be preliminarily detected by constructing similar correlation matrices. By grouping various mean scores with different demographic variables, hopefully interesting associations in more detail could be revealed through similar types of correlation matrices. After running correlation matrices of mean scores grouped by different levels of all demographic variables, few with interesting results are highlighted and listed in the following tables. Table C-2, correlation table of mean scores grouped by Primary Language=2, Spanish, illustrates that among those whose primary language is Spanish, children's performances in Visual Arts and Mathematics tend to be highly correlated. Interestingly, children's performances in Visual Arts and Performing Arts; Language Arts and Visual Arts; and Mathematics and Performing Arts are also relatively correlated.

	Language Arts	**Visual Arts**	**Mathematics**	**Sciences**	**Performing Arts**
Language Arts	1				
Visual Arts	**0.8328415**	1			
Mathematics	0.6735147	**0.9171312**	1		
Sciences	0.1236774	0.5437456	0.4531454	1	
Performing Arts	0.7875605	**0.8690377**	**0.8127256**	0.5761357	1

Table C-2: Correlations of Mean Scores by Primary Language=2 (Spanish)

In Table C-3, correlations among mean scores grouped by Ethnicity=1, Latino are listed. Similar to results displayed in Table C-1, among children who are Latino, their performances in Visual Arts and Mathematics are highly correlated. However, not correlations in all other areas are similar. Among Latino children, performances in Language Arts and Visual Arts; Language Arts and Mathematics; and Visual Arts and Sciences are relatively correlated.

	Language Arts	Visual Arts	Mathematics	Sciences	Performing Arts
Language Arts	1				
Visual Arts	**0.8387402**	1			
Mathematics	**0.8105759**	**0.9235173**	1		
Sciences	0.7227435	**0.8763908**	0.7638148	1	
Performing Arts	0.4831225	0.6723707	0.7622932	0.4582029	1

Table C-3: Correlations of Mean Scores by Ethnicity=1 (Latino)

In table C-4, correlations of mean scores grouped by Ethnicity=4, Asian/Pacific Islander are listed. Surprisingly, two correlations over .9 illustrate that among those who are Asian/Pacific Islander, children's performances in Language Arts and Mathematics; and Language Arts and Sciences are very highly correlated. Also, performances in Mathematics seem to be highly correlated with Sciences. Interestingly, two relatively high negative correlations are present between Language Arts and Performing Arts; and Sciences and Performing Arts. This suggests that among children who are Asian/Pacific Islander, the performances in Language and Performing Arts; and Sciences and Performing Arts are strongly negatively correlated—moving in opposite directions. These negative correlations are somewhat unique and do not seem to appear in other demographic variables.

	Language Arts	Visual Arts	Mathematics	Sciences	Performing Arts
Language Arts	1				
Visual Arts	-0.2612353	1			
Mathematics	**0.9125717**	-0.6331131	1		
Sciences	**0.9989518**	-0.2167775	**0.8928977**	1	
Performing Arts	**-0.8742704**	-0.2401922	-0.5993301	**-0.8955742**	1

Table C-4: Correlation of Mean Scores by Ethnicity =4 (Asian/Pacific Islander)

Table C-5 contains correlations of mean scores grouped by Ethnicity=6 (Bi-Mixed-race). Clearly there are very high associations present between Language Arts and Visual Arts; Language Arts and Mathematics; and Visual Arts and Mathematics for children who are

Bi/Mixed race. Language Arts and Performing Arts; Visual Arts and Performing Arts; and Mathematics and Sciences are also relatively highly correlated. Unlike Ethnicity=4, Asian/Pacific Islander, children with Mixed race tend to perform similarly in areas like Language Arts and Visual Arts; and Language Arts and Mathematics; and Visual Arts and Mathematics.

	Language Arts	**Visual Arts**	**Mathematics**	**Sciences**	**Performing Arts**
Language Arts	1				
Visual Arts	**0.9992004**	1			
Mathematics	**0.9514076**	**0.9383349**	1		
Sciences	0.6087635	0.5765567	**0.8234826**	1	
Performing Arts	**0.8241691**	**0.8461538**	0.6097239	0.0524144	1

Table C-5: Correlation of Mean Scores by Ethnicity =6 (Bi/Mixed-race)

The tables above are only few interesting results/summaries among all correlation matrices constructed.* These correlations serve as preliminary assessments for possible patterns present among different scores and scores grouped by different demographics. In conclusion, performances in some areas are likely to be tied by demographic variables. Furthermore, ethnicity and primary language appear to have associations with children's performances in various areas.

* Among all correlation matrices constructed, only the ones contain ANY value above .9 are listed in this section.

D. Single-Response Regressions

By building single-response regressions, one hopefully can see the relationships between various demographic variables and different types of mean scores. Single-response regressions are constructed based on the mean-score dataset, in which five types of mean scores are calculated per student after removal of observations with missing values. In these single-response regressions, associations between demographic information and a certain type of exam can be further assessed. In the following single-response regressions,

since school id is more refined than grade, school id instead of grade is included as a covariate.

D-1. Language Arts

By having mean score- Language Arts as response, school id, ethnicity, gender, socio-economic status and primary language as covariates, a linear regression can hopefully examine the significant terms of children's performance in Language Arts. As shown in Table D-1, school id and ethnicity seem to be significant covariates in terms of predicting children's performance in Language Arts at test level $\alpha = .05$. Comparing with children in school 1, children in school 3 tend to perform most poorly in Language Arts, adjusting for all other covariates. Interestingly, school 3 and 4 share one thing in common- all children belong to Pre-Kindergarten. In the aspect of ethnicity, comparing with children with ethnicity = Latino, Caucasian children tend to score the highest in the area of Language Arts, adjusting for the rest of covariates. Interestingly, thought insignificant, female children tend to perform relatively better in Language Arts adjusting for all other covariates. Socio-economic status and primary language do not seem to play significant roles in terms of predicting children's performance in Language Arts.

	Estimate	**Std. Error**	**p-value**
Intercept	4.49092	0.62074	**1.18e-09**
school.id=2	-0.45383	0.57693	0.434704
school.id=3	-2.36048	0.62973	**0.000412**
school.id=4	-1.49321	0.51870	**0.005582**
ethnicity=Af-Am.	0.59503	0.55921	0.291713
ethnicity=Cauca.	1.31646	0.58890	**0.029252**
ethnicity=Asian	1.18589	0.78340	0.135516
ethnicity=Bi/Mixed	-0.26342	0.82793	0.751503
ethnicity=Middle E.	0.29595	0.96325	0.759758
gender=male	-0.16188	0.28686	0.574717
econ.stat=middle	0.10726	0.64865	0.869242
econ.stat=upper	-0.09966	0.65911	0.880342
prim.lang=Spanish	-0.14298	0.76575	0.852536
prim.lang=other	1.16902	1.17411	0.323549

Table D-1: Summary of linear model d1, where d1 is
mean score "Lang. Arts" =school+ ethnicity + gender + econ + lang + ε

where $\varepsilon \sim_{iid} N(0, \sigma^2)$

D-2. Visual Arts

When building single-response regression on mean scores of Visual Arts, at $\alpha = .05$, school id, ethnicity and gender appear to be significant covariates in terms of predicting children's performance in Visual Arts. Adjusting for all other covariates, comparing with children in school 1, children in school 3 tend to have the lowest mean scores in Visual Arts. In addition, school 3 and 4 only consist of children who are in Pre-Kindergarten. Although children in both school 1 and 2 are in Kindergarten, school 1 contains more of a variety in terms of ethnicity and socio-economic status. Comparing with Latino children, children with ethnicity= Asian/Pacific Islander tend to have the highest mean score in Visual Arts, adjusting for other covariates. In the area of Visual Arts, adjusting for all other covariates, female children tend to have better performances. Though insignificant, comparing with children in socio-economic status= low, children in middle and upper classes tend to have relatively lower mean scores in Visual Arts adjusting for other covariates. Primary language does not appear to be a significant predictor for children's performance in Visual Arts.

	Estimate	**Std. Error**	**p-value**
Intercept	6.097384	0.492471	**< 2e-16**
school.id=2	-1.345190	0.457713	**0.00472**
school.id=3	-3.024933	0.499606	**1.11e-07**
school.id=4	-2.192069	0.411518	**1.70e-06**
ethnicity=Af-Am.	0.746323	0.443657	0.09791
ethnicity=Cauca.	1.085601	0.467211	**0.02367**
ethnicity=Asian	1.264781	0.621523	**0.04643**
ethnicity=Bi/Mixed	-0.26342	0.656849	0.97224
ethnicity=Middle E.	0.540227	0.764209	0.48245
gender=male	-0.537611	0.227583	**0.02154**
econ.stat=middle	-0.168600	0.514613	0.74438
econ.stat=upper	-0.009339	0.522916	0.98581
prim.lang=Spanish	0.268885	0.607518	0.65970
prim.lang=other	0.215295	0.931495	0.81803

Table D-2: Summary of linear model d2, where d2 is
mean score "Visual Arts" =school+ ethnicity + gender + econ + lang + ε
where $\varepsilon \sim_{iid} N(0, \sigma^2)$

D-3. Mathematics

In the area of Mathematics, at $\alpha = .05$, school id and ethnicity are significant factors. Comparing with children in school 1, children in school 3 tend to have the lowest mean scores in Mathematics adjusting for other covariates. In detail, school 3 and 4 both consist of children in Pre-Kindergarten though children in school 3 only belong to socio-economic status= low. Comparing with Latino children, children with ethnicity=Asian/Pacific Islander tend to have the highest mean scores in Mathematics adjusting for other covariates. Though insignificant, female children tend to have relatively better performances in Mathematics adjusting for other covariates. Although socio-economic status is insignificant, comparing with children in socio-economic status=low, those who belong to upper tend to perform relatively better adjusting for other covariates. Even though primary language is insignificant, comparing with children with primary language=English, those with primary language=other tend to perform better in the area of Mathematics.

	Estimate	**Std. Error**	**p-value**
Intercept	5.88310	0.60749	**1.01e-13**
school.id=2	-0.80514	0.56462	0.159230
school.id=3	-2.56168	0.61629	**0.000108**
school.id=4	-1.55359	0.50763	**0.003345**
ethnicity=Af-Am.	0.67695	0.54728	0.221092
ethnicity=Cauca.	1.30762	0.57633	**0.027014**
ethnicity=Asian	2.33265	0.76669	**0.003521**
ethnicity=Bi/Mixed	0.85280	0.81026	0.296939
ethnicity=Middle E.	0.06069	0.94270	0.948892
gender=male	-0.51576	0.28074	0.071312
econ.stat=middle	-0.07391	0.63481	0.907716
econ.stat=upper	0.37483	0.64505	0.563435
prim.lang=Spanish	0.35883	0.74941	0.633870
prim.lang=other	1.25254	1.14906	0.280196

Table D-3: Summary of linear model d3, where d3 is
mean score "Mathematics" =school+ ethnicity + gender + econ + lang + ε
where $\varepsilon \sim_{iid} N(0, \sigma^2)$

D-4. Sciences

From Table D-4, at α = .05, one can see that only school id is significant in terms of predicting children's performance in Sciences. Comparing with children in school 1, those in school 4 tend to have the lowest mean scores in Sciences, adjusting for other covariates. In addition, children in school 4 (and school 3) are in Pre-Kindergarten. Although insignificant, comparing with Latino children, children with Asian/Pacific Islander background tend to have the highest mean scores in Sciences. Even though socio-economic status appears to be insignificant as well, as socio-economic status increases, mean scores in Sciences tend to increase adjusting for other covariates. Though insignificant, comparing with children whose primary language is English, children whose primary language is Spanish tend to have relatively low scores while those with primary language= other tend to have relatively high scores.

	Estimate	**Std. Error**	**p-value**
Intercept	3.76961	0.42648	**2.45e-12**
school.id=2	-0.50908	0.39638	0.2041
school.id=3	-0.79956	0.43266	0.0697
school.id=4	-0.92683	0.35638	**0.0118**
ethnicity=Af-Am.	0.17110	0.38421	0.6577
ethnicity=Cauca.	0.16019	0.40461	0.6936
ethnicity=Asian	0.98065	0.53824	0.0736
ethnicity=Bi/Mixed	0.14884	0.56883	0.7945
ethnicity=Middle E.	-0.36396	0.66181	0.5845
gender=male	0.01101	0.19709	0.9556
econ.stat=middle	0.25499	0.44566	0.5694
econ.stat=upper	0.63888	0.45285	0.1636
prim.lang=Spanish	-0.26446	0.52611	0.6171
prim.lang=other	0.73103	0.80668	0.3686

Table D-4: Summary of linear model d4, where d4 is
mean score "Sciences" =school+ ethnicity + gender + econ + lang + ε
where $\varepsilon \sim_{iid} N(0, \sigma^2)$

D-5. Performing Arts

As shown in Table D-5, at test level $\alpha = .05$, only school id is significant in terms of predicting children's performance in Performing Arts. Comparing with children in school 1, those in school 3 tend to have the lowest scores in Performing Arts, adjusting for other covariates. Notice that school 3 only consists of children who are in Pre-Kindergarten (as does school 4) and who belong to socio-economic status= low. Even though ethnicity=African American has a p-value of .066, insignificant at $\alpha = .05$, comparing with Latino children, those with African American background tend to have the highest scores in Performing Arts. Gender, socio-economic status and primary language are not significant covariates in terms of predicting performance in Performing Arts. However, females tend to perform relatively better in the area of Performing Arts. In addition, comparing with children who belong to socio-economic status=low, those with socio-economic status=high tend to have lowest score in Performing Arts, adjusting for other covariates. Comparing with children whose primary language= English, those whose primary language=other tend to have lower means.

	Estimate	**Std. Error**	**p-value**
Intercept	4.43517	0.55160	**5.24e-11**
school.id=2	-0.65742	0.51267	0.2048
school.id=3	-1.40830	0.55960	**0.0146**
school.id=4	-0.58976	0.46093	0.2058
ethnicity=Af-Am.	0.93116	0.49693	0.0660
ethnicity=Cauca.	0.32256	0.52331	0.5401
ethnicity=Asian	0.76179	0.69615	0.2784
ethnicity=Bi/Mixed	-0.46008	0.73572	0.5342
ethnicity=Middle E.	0.07809	0.85597	0.9276
gender=male	-0.22993	0.25491	0.3708
econ.stat=middle	0.18474	0.57641	0.7497
econ.stat=upper	-0.81576	0.58571	0.1690
prim.lang=Spanish	0.47179	0.68047	0.4909
prim.lang=other	-1.28945	1.04334	0.2215

Table D-5: Summary of linear model d5, where d5 is
mean score "Performing Arts" =school+ ethnicity + gender + econ + lang + ε
where $\varepsilon \sim_{iid} N(0, \sigma^2)$

E. Full Model: Linear Mixed-Effect Model

In addition to knowing the nature of the data and the preliminary associations present among demographic characteristics and different types of performances, a mixed-effect model is built to capture and explain the relationship between demographic variables and scores in general. This mixed-effect model is built based on the original dataset after removing observations with missing values, in which each row represents an observation- a score of one test of an individual. This complete case dataset again contains 2516 observations, 84 unique individuals. Since the observations are measurements of the same individuals in various areas, subject id is treated as a random effect during model fitting. By assigning subject id to be random, correlations among observations are considered.

Displayed in Table E-1, one can see that at test level α=.05, grade, ethnicity and number of repetition of an exam are significant covariates in terms of predicting children's performances. In further detail, comparing with children in pre-kindergarten, those in kindergarten tend to have higher scores in general, adjusting for all other covariates. Comparing with Latino children, Asian and Caucasian children appear to have relatively higher scores by 1.48 and 1.05 units respectively, adjusting for other covariates. In addition, regarding number of repetition of an exam, at α=.05, children's scores of an exam at a second time are relatively higher than that at the first time by .65 units, adjusting for other covariates. Interestingly, gender, number of full time adults, socio-economic status and primary language are insignificant factors which may affect children's performances at α=.05.

By looking at Table E-2, correlation among different types of scores within a child can be obtained as of the following:

$\sigma^2_{subject} / (\sigma^2_{subject} + \sigma^2_{all}) = .437 / (.437 + 3.72) = .105$

Such a low correlation of .105 suggests that within a child, performances in various areas are very slightly correlated. In other words, among a child's performances in various areas, scores tend to be very jagged.

.

	Estimate	Std. Error	t-value
Intercept	2.181558	0.599076	**3.6415**
grade=kindergarten	1.454422	0.299254	**4.8602**
gender=male	-0.268639	0.179666	-1.4952
ft.adults=2	0.594257	0.349748	1.6991
ft.adults=3	0.083492	0.448894	0.1860
ethnicity= Af-Am.	0.550950	0.371576	1.4827
ethnicity= Cauca.	1.051571	0.386369	**2.7217**
ethnicity= Asian	1.478794	0.525147	**2.8160**
ethnicity=Bi/Mixed	0.192339	0.562346	0.3420
ethnicity=Middle E.	0.148005	0.630805	0.2346
econ.stat=middle	0.167338	0.307950	0.5434
econ.stat=upper	0.161269	0.391638	0.4118
prim.lang=Spanish	0.082272	0.513410	0.1602
prim.lang=other	-0.284739	0.640124	-0.4448
area= Visual Arts	0.897512	0.125843	**7.1320**
area=Math	1.158261	0.107449	**10.7796**
area=Sci	-0.678395	0.135326	**-5.0131**
area=Perf. Arts	0.141747	0.128486	1.1032
time=2	0.647702	0.079881	**8.1083**

Table E-1: Summary of radom-effect model e1, where e1 is
score=subject id +grade + gender + ft.adults + ethnicity + econ +lang + type.of.act + time
where subject id is treated as a random effect

Groups	Name	Variance	Std. Dev.
subject.id	**Intercept**	0.43774	0.66162
Residual		3.72355	1.92965

Table E-2: Summary of Random Effects—model e1
** number of obs=2516, groups=subject.id, 84

By eliminating full time adults, random-effect model e2, shown in Table E-3 has lower AIC and BIC. In addition, socio-economic status becomes statistically significant at test level α=.05. In model e2, the summary suggests that comparing with children who belong to socio-economic status = low, those who belong to higher socio-economic status tend to have relatively better performances. In conclusion, at α=.05, grade, ethnicity, socio-economic status and number of repetition of an exam are significant covariates in terms of predicting children's performances.

	Estimate	**Std. Error**	**t-value**
Intercept	2.581075	0.401912	**6.4220**
grade=kindergarten	1.361034	0.215066	**6.3285**
gender=male	-0.243427	0.334526	-1.3448
ethnicity= Af-Am.	0.351882	0.334526	1.0519
ethnicity= Cauca.	0.950791	0.376227	**2.5272**
ethnicity= Asian	1.515046	0.530394	**2.8565**
ethnicity=Bi/Mixed	0.072948	0.558345	0.1306
ethnicity=Middle E.	0.412428	0.621168	0.6640
econ.stat=middle	0.515202	0.234241	**2.1995**
econ.stat=upper	0.524461	0.342444	1.5315
prim.lang=Spanish	-0.205457	0.495868	-0.4143
prim.lang=other	-0.216954	0.637329	-0.3404
area= Visual Arts	0.901178	0.125829	**7.1619**
area=Math	1.161183	0.107442	**10.8075**
area=Sci	-0.678395	0.135306	**-5.0220**
area=Perf. Arts	0.144209	0.128480	1.1224
time=2	0.641325	0.079752	**8.0415**

Table E-3: Summary of radom-effect model e2, where e2 is
score=subject id +grade + gender + ethnicity + econ +lang + type.of.act + time
where subject id is treated as a random effect

Groups	**Name**	**Variance**	**Std. Dev.**
subject.id	**Intercept**	0.45013	0.67092
Residual		3.72363	1.92967

Table E-4: Summary of Random Effects—model e2
** number of obs=2516, groups=subject.id, 84

IV. Conclusion

Sociologists and educators continuously search for possible patterns or relationships present among children's performances and their demographic characteristics. Seeing patterns and associations, new strategies and recommendations can be established toward education development. While demographic characteristics of the 92 children such as grade, gender, ethnicity, socio-economic status, number of full-time adults, primary language, and number of repetition of an exam are included in the study, the goal is to find possible associations present between the demographic characteristics and children's performances in areas like Language Arts, Visual Arts, Mathematics, Sciences, and Performing Arts.

By building correlations among different types of mean scores and among those with different groupings, the preliminary assessments suggest that children's performances shift and move toward the same direction in areas such as Language Arts, Mathematics, and Visual Arts. In addition, there are a few correlations over .9 among mean scores with different groupings. With a correlation of .92, among children who are Latino, their performances in Visual Arts and Mathematics are highly correlated. With correlations of .91 and .99, among those who are Asian/Pacific Islander, children's performances in Language Arts and Mathematics; and Language Arts and Sciences are very highly correlated. Interestingly, for children who are Asian/Pacific Islander, with relatively high negative correlations of -.63 and -.59, their performances in Language and Performing Arts; and Sciences and Performing Arts tend to move in opposite directions. Lastly with correlations of .99, .95, and .94, children with Mixed race tend to perform similarly in areas like Language Arts and Visual Arts; and Language Arts and Mathematics; and Visual Arts and Mathematics.

From results of single- response regressions, one can find that for each type of exam, terms which are significant in terms of predicting performances indeed vary. For Language Arts, school id, grade and ethnicity seem to be significant covariates. For Visual Arts, school id, grade, ethnicity and gender appear to be significant covariates. In the area of Mathematics, at $\alpha = .05$, school id, grade and ethnicity are significant factors.

Surprisingly, only school id is significant in terms of predicting children's performance in Sciences, although its significance can arguably be attributed to differences in grade levels. Furthermore, only school id is significant in terms of predicting children's performance in Performing Arts as well.

Since correlations and single-response regressions serve as preliminary tools that identify possible associations, a linear mixed effect model is built to summarize the relationship between demographic characteristics and children's scores in general. The results of the linear mixed effect model suggests that at α=.05, grade, socio-economic status, ethnicity and number of repetition of an exam are significant covariates in terms of predicting children's scores. Moreover, comparing with children in pre-kindergarten, those in kindergarten tend to have higher scores in general, adjusting for all other covariates. Comparing with children who belong to socio-economic status = low, those who belong to higher socio-economic status tend to have relatively better performances. Comparing with Latino children, Asian and Caucasian children appear to have relatively higher scores by 1.48 and 1.05 units respectively, adjusting for other covariates. Interestingly, regarding number of repetition of an exam, at α=.05, children's scores of an exam at a second time are relatively higher than that at the first time by .65 units, adjusting for other covariates.

By reading the correlation present among different type of scores within a child, one discovers that performances in different areas from one child only tend to be slightly correlated with one another. This suggests that each child indeed has his or her own learning profile- scores in one area cannot function as good indication or evaluation for performances in another.

Acknowledgements

We thank Professor J. Chen of Erikson Institute for her expert insights and for providing us with the data.

References

Bryk, Anthony S. and Raudenbush, Stephen W. (1992). *Hierarchical Linear Models*, SAGE Publications: California.

Long, J. S. (1997). *Regression Models for Categorical and Limited Dependent Variables*, SAGE Publication: California.

Mead, R. (1990). *The Design of Experiments*, Cambridge University Press: New York.