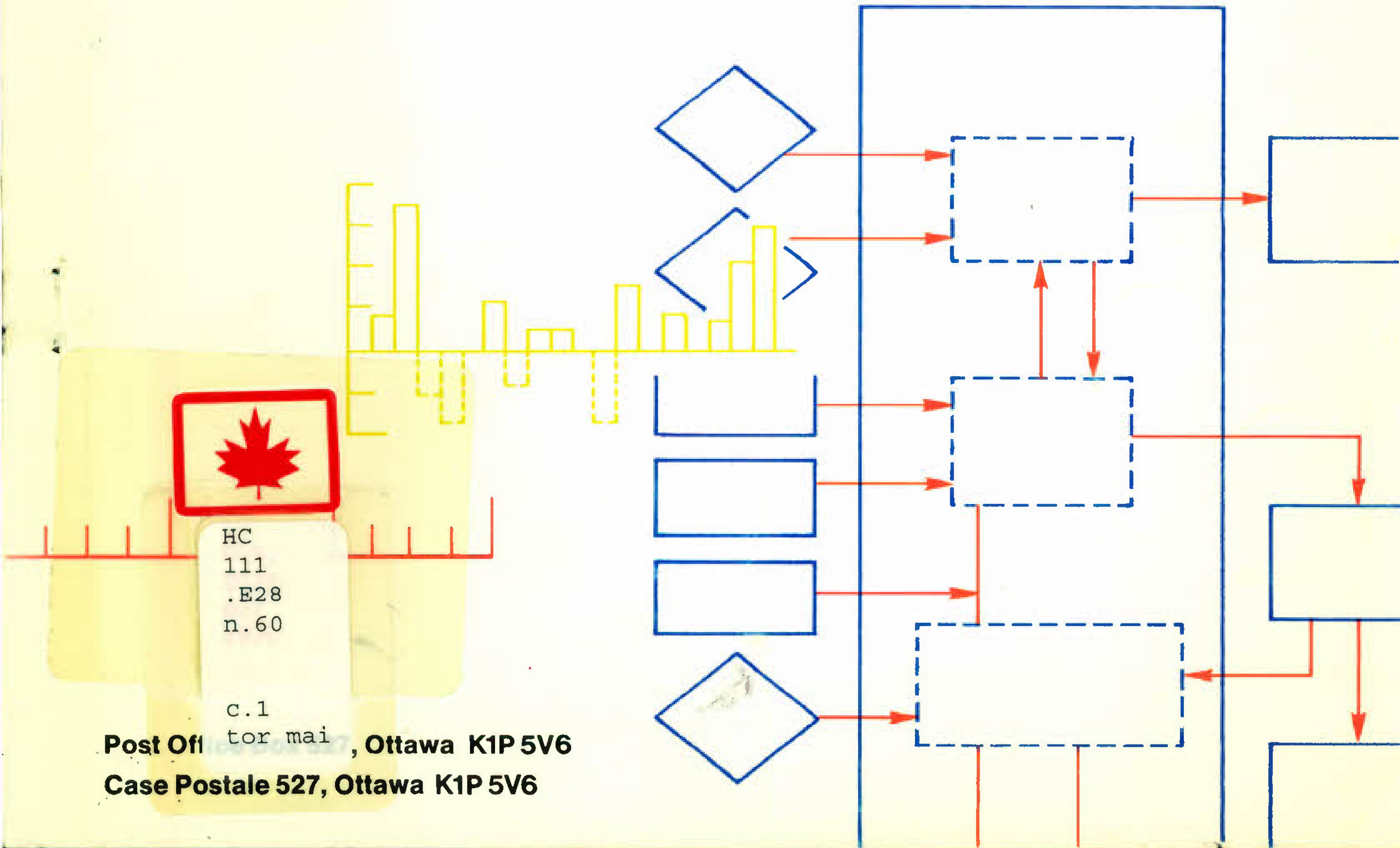

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DISCUSSION PAPER NO. 60

A Further Look at the Determinants of Educational Achievement

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July 1976

Abstract

This paper considers the effects of home and school environments on students' educational achievement in reading and writing as part of a co-operative project with the Ministry of Education of Ontario. Our basic unit for analysis is the grade seven student attending a school of one Ontario School Board within the 1972-73 school year. Least-squares estimates for the parameters of several alternative educational production functions are presented. Both their significance and their robustness are explored.

Our empirical results suggest that peer influences markedly affect achievement, that there exists a positive relationship between class size and achievement, and that the years of professional experience of teachers is important. A number of secondary conclusions are drawn with respect to the influences of school resources (including the provision of equipment, facilities for physical education and the organization of open-space and continuous progress teaching methods), teachers' attributes, student densities in schools, and the average income of the school neighbourhood.

Introduction

Many aspects of our school systems have been subjected to critical review in recent years. Some critics cite particular shortcomings that they identify among the characteristics of the present generation of pupils. Thus, for example, concern has often been expressed with respect to levels of scholastic achievement (especially in traditional subject areas such as reading, writing, and arithmetic) and to forms of social intercourse both among the members of particular peer groups and between children and adults. Other critics primarily define shortcomings by comparing these educational outputs to the magnitudes of both monetary and real inputs for our schools. Particular inputs that have been used in this way include levels of expenditures, the number of teachers, average class sizes, and levels in the provision of supplementary aids such as library facilities, film projectors and television sets.

A number of problems must be faced by the researcher when he attempts to clarify the empirical bases of both sets of criticisms. These problems can be conveniently assigned to the four broad categories associated with measurement, specification, availability of data, and estimation. The first category involves questions of defining appropriate measures for educational inputs and outputs while the second one deals with the difficulties experienced in attempting to specify stable relationships between these two sets of variables (which may not be distinct in a dynamic sense since some outputs can also serve as intervening inputs)[1]. In this paper, both of these categories are left relatively unexplored. Instead we shall focus our attention on problems contained in the other two categories. Thus, we shall emphasize the need for collation of more comprehensive and accurate panels of data at the individual level and the need for development of appropriate procedures to manipulate these data so that they assist in the resolution of areas of dispute.

This present report was undertaken as part of a cooperative project with the Ministry of Education of Ontario. It is the fourth in a series on education. The first one suggested a conceptual framework linking educational inputs and outputs, while the other reports, as well as this document, present new sources of Canadian data that link the characteristics of individual students, their school environments, and their levels of achievement as reflected in standardized test scores. The background for earlier reports by J. Greenberg[2] and by J. V. Henderson, P. Mieszkowski and Y. Sauvageau[3] is briefly described below. This earlier work and the material presented in this document are based on observations for

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1 Discussions of intervening variables are provided by O. D. Duncan, D. L. Featherman and B. Duncan, *Sociological Background and Achievement* (New York: Seminar Press, 1972) and by E. Hanushek, "Teacher Characteristics and Gains in Student Achievement: Estimation Using Micro Data", *American Economic Review, Papers and Proceedings*, Vol. 61, No. 2, 1971, pp. 280-288.

2 J. Greenberg, *Social Indicators in Education: A Conceptual Framework*, Discussion Paper No. 6 (Economic Council of Canada, 1974); *Social Indicators in Education: A Case Study*, Discussion Paper No. 15 (Economic Council of Canada, 1974).

3 J. V. Henderson, P. Mieszkowski and Y. Sauvageau, *Peer Group Effects and Educational Production Functions* (Ottawa: Information Canada, forthcoming in 1976).

individual students and illustrate the tentative use of such micro data to explore the determinants of students' achievement within the framework of educational production functions or input-output processes. This research reflects a view that some aspects of these processes can better be explored with micro data than with the aggregate data such as assembled in large-scale survey studies by the International Association for the Evaluation of Educational Achievement (IEA) and by J. Coleman and his associates for the National Center for Educational Statistics in the United States[4].

There are three sections below. An outline of our basic research framework is followed by descriptions of the diverse sources of our data and of a matching procedure for the data. In the third section, some empirical results are then presented. Here, estimates of regression coefficients are tabulated, their significance discussed, and their sensitivity explored. Three appendices contain an alternative set of results, a list of variables for which data are available, and both the mean values and standard deviations of those variables used in our research.

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4 T. Husén (ed.), *The International Study of Achievement in Mathematics* (New York: John Wiley and Sons, 1967); J. S. Coleman et al., *Equality of Educational Opportunity* (Washington, D.C.: U.S. Government Printing Office, 1966).

Basic Framework for Research

The production function or input-output approach to educational achievement has been extensively described by Averch and his associates in a widely-distributed report that was prepared for the Rand Corporation[5]. A brief summary was also contained in Greenberg's first report. The approach has a long history of use by economists although problems of measuring educational outputs probably delayed use of the approach in educational research. With this approach, educational inputs and outputs are first specified and then associated in a single equation or in several equations. Our particular choices can be displayed in the following symbolical form:

$$A = f(S, T, C, K, P)$$

where A denotes achievement on a standardized test in a given subject (reading or writing) and $f(.)$ represents the functional relationship linking achievement to its determinants. S, T, C, K and P denote distinct collections of variables representing socio-economic status, features of teachers (including age, experience and organizational methods), student characteristics, aspects of school plant, and peer-group influences, respectively.

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5 H. A. Averch, *How Effective is Schooling? A Critical Review and Synthesis of Research Findings* (Santa Monica, California: The Rand Corporation, 1972).

In this abstract form, the production-function approach provides a suitable organizational framework for exploring the impact of some determining variables or inputs on educational achievement. Both discontinuous and qualitative influences can be integrated into this framework. The transformation from an abstract form to a regression equation that can be used as a basis for empirical research and the precise estimation of unknown parameters in this equation are, however, often difficult. Basic concerns stem from the relative adequacies of different representations of the regression equation and from the properties of estimates of its coefficients. The transformation usually has two stages. First, partial specification of the function $f(.)$ is attempted. An equation linear in its unknown parameters is a conventional choice here and this specification is the one adopted for this report and the earlier ones cited above. For the second stage, a shift from a deterministic relationship linking inputs to outputs to a stochastic one is represented by the introduction of a supplemental random component. This new "error term" reflects the composite impact of all active factors that have been omitted from the list of explicit determining factors. Unfortunately, the distributional properties of this additional term crucially affects the reliability of estimated coefficients and, hence, the relative success of the production-function approach.

Some statistical requirements are especially important if least-squares estimates of regression coefficients are to be used. We require that the error terms associated with different pupils be uncorrelated (so that omitted factors are not the source of hidden interactions among pupils that may distort the particular linkages revealed by estimated coefficients), that these terms be uncorrelated with variables that are explicitly introduced in the equation (so that the impacts of omitted and included variables are not confused), and that the values of S, T, C, K and P variables be sufficiently distinct for regression coefficients to be precisely estimated. In addition, we require that these coefficients are stable across the pupil population. When these requirements are not met, least-squares estimates can be substantially biased and inefficient relative to other estimates. The report by Henderson, Mieszkowski and Sauvageau illustrates the use of an alternative estimation procedure when sets of the error terms are assumed to be correlated. We consider the question of instability when presenting some estimates below.

The literature on educational achievement abounds with studies that have used the production-function approach and have assumed fulfilment of all of these statistical requirements. In early studies, the unit of observation was often the school or the school district so that aggregation obscured some influences of potential relevance, for example the interaction within peer groups of pupils. The use of micro data for individual pupils might help to clarify the forms and relative importance of this interaction. As Michelson argues, it is "reasonable, preferable, and statistically valid to consider children as observations" and it is "reasonable and preferable because the object of the investigation is to determine the effects of variables on children, not on schools"[6]. Hence several recent studies have attempted to use data recording the educational achievements of individual pupils and certain characteristics of their environments, including features of their classmates, to explore the so-called "peer group effects" on educational achievement. One such attempt by Greenberg is contained in an earlier report in this series. Greenberg used data from a school board in Ontario to explore the direct, indirect and total impacts of peer groups and other factors on achievement. His path models are a simple extension of the research framework that is sketched above.

The study by Henderson, Mieszkowski and Sauvageau also addresses the question of peer group effects using a variant of our research framework. Its basic source of information is a large sample of micro data for pupils within the Montreal school system. Given historical data, Henderson, Mieszkowski and Sauvageau were able to derive values for previous levels of achievement and so to trace the temporal evolution of achievement by individual pupils. Their underlying theoretical model (which determines the choice of variables for S, T, C, K and P) reflects the earlier work by Hanushek with

6 S. Michelson, "The Association of Teacher Resourceness with Children's Characteristics", in *Do Teachers Make A Difference?* by A. Mood et al. (Washington, D.C.: U.S. Government Printing Office, 1970), p. 128.

its emphasis on cumulative influences[7]. We are less fortunate with data availability for this present report and cannot consider questions arising from the historical embodiment of skills. Our primary data were made available by a second school board in Ontario and we have been unable to match pupils or teachers in different time periods.

One final difficulty can seriously affect the fruitful use of the basic research framework outlined above. This seems to have been recognized since the publication of the Coleman Report[8] in 1966. Even when data are available at appropriate levels of disaggregation, these data are seldom orthogonal enough to allow for the separate influences of various inputs to be distinguished. Thus, there frequently occur situations in which the researcher is required to exercise his personal judgement. Unfortunately, we have not yet devised simple techniques to resolve the areas of controversy that arise when two researchers draw differing conclusions from the same empirical evidence. This difficulty may be exemplified by the recent debate concerned with alternative techniques for assessing the relative contribution of explanatory factors in the determination of educational achievement.

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7 E. Hanushek, "The Production of Education, Teacher Quality, and Efficiency", in *Do Teachers Make A Difference?* by A. Mood et al. (Washington, D.C.: U.S. Government Printing Office, 1970).

8 J. S. Coleman et al., *Equality of Educational Opportunity* (Washington, D.C.: U.S. Government Printing Office, 1966).

This debate[9] stems from the bases of conclusions drawn during the pioneer work on peer group effects by Coleman and his associates. Mood has described the judgement process that was adopted in the Coleman Report[10].

> "In analyzing the Equal Educational Opportunity Survey data (Coleman et al.) we decided to partition variance rather than use regression coefficients because we were concerned with broad factors (such as motivation, family support, community support, support of peers, teacher capability) that influence education and we had only rudimentary indicators for many of them. We doubted that regression coefficients of the indicators would give us reliable insights; hopefully the proportion of variance associated with a given factor via its set of indicators would not change radically when in the future other investigators and other investigations used other sets of indicators for that factor. That is, our fundamental assumption in choosing the method of analysis was that the proportion of variance associated with a factor would have more stability than would regression coefficients of the indicators of the factor."

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9 The following list contains some contributions to this debate: S. Bowles and H. M. Levin, "The Determinants of Scholastic Achievement -- An Appraisal of Some Recent Evidence", *The Journal of Human Resources*, Vol. 3, No. 1, 1968, pp. 3-24; G. G. Cain and H. W. Watts, "The Problems in Making Policy Inferences from the Coleman Report", *American Sociological Review*, Vol. 35, No. 1, 1970, pp. 228-252 (including a Reply by J. S. Coleman and a Comment by D. J. Aigner); R. P. Carver, "The Coleman Report: Using Inappropriately Designed Achievement Tests", *American Educational Research Journal*, Vol. 12, No. 1, 1975, pp. 77-86; J. A. Creager, "Orthogonal and Nonorthogonal Methods for Partitioning Regression Variance", *American Educational Research Journal*, Vol. 8, No. 4, 1971, pp. 671-676; E. A. Hanushek and J. F. Kain, Ch. 2 of *On Equality of Educational Opportunity*, (eds.) F. Mosteller and D. P. Moynihan (New York: Random House, 1972); A. M. Mood, "Partitioning Variance in Multiple Regression Analyses as a Tool for Developing Learning Models", *American Educational Research Journal*, Vol. 8, No. 2, 1971, pp. 191-202; J. H. Ward, Jr., "Partitioning of Variance and Contribution or Importance of a Variable: A Visit to a Graduate Seminar", *American Educational Research Journal*, Vol. 6, No. 3, 1969, pp. 467-474; C. E. Werts, "The Partitioning of Variance in School Effects Studies", *American Educational Research Journal*, Vol. 5, No. 3, 1968, pp. 311-318.

10 A. M. Mood, "Partitioning Variance in Multiple Regression Analyses as a Tool for Developing Learning Models", *American Educational Research Journal*, Vol. 8, No. 2, 1971, p. 197.

Although criticisms of the use of significance tests in non-experimental situations were commonplace among sociologists[11], this particular approach leads to a sustained and adverse response primarily, but not exclusively, from economists. Cain and Watts[12] illustrate this response when they assert

> "... in those instances where a theoretical justification for the use of a variable in the regression model is clear, the criterion used in the Coleman Report to assess or evaluate the statistical performance of the variable is inappropriate. Instead of providing information about the quantitative effect of a variable in altering educational achievement -- information which would enable the reader to assess the feasibility and costliness of operating on the variable -- the Report provides information about a statistical measure of the variable's performance (namely, its effect on the coefficient of determination, or R^2, of the regression), which gives no clear guidance for translating the statistical findings into policy action."

No resolution of the initial difficulty has yet emerged from this debate so the researcher remains in a quandary. In this report, we cite F statistics and use their values as crude indicators of the relevance of particular inputs but we remain acutely aware of the deficiencies of total reliance on this basis for judgement.

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11 See, for example, the comments assembled by D. E. Morrison and R. E. Henkel in *The Significance Test Controversy -- A Reader* (Chicago: Aldine Publishing Company, 1970), including those partially attributable to Coleman.

12 G. G. Cain and H. W. Watts, "Problems in Making Policy Inferences from the Coleman Report", *American Sociological Review*, Vol. 35, No. 1, 1970, p. 229.

Data -- Sources, Specifications and Matching Procedures

The sources of our sets of data are diverse. Initially, the Fernandez[13] School Board in Ontario provided data reflecting ages, achievement, and intelligence scores of pupils for several years and for several grades. Also from this board we received socio-economic information which unfortunately in certain interesting areas was quite incomplete and hence of limited value to us. From the Ontario Ministry of Education in Toronto we obtained much background information on teachers throughout the province for 1971-72 and 1972-73 and data on the resources of all Ontario schools for the years 1968 through 1972. One final source of data was a 1971 Census tape with information on households, classified by census tract.

Computer printouts from the Fernandez School Board provided us with three sets of information, namely, pupil age in months, STEP scores, and SFTAA scores. STEP, short form for Sequential Test of Educational Progress, attempts to assess pupils in basic skills and concepts inherent in most courses of study, namely, reading, writing, science, and mathematics. Administered in mid-year to grades four to eight, STEP is a measure of achievement used to evaluate the growth and the rate of growth of development. SFTAA or Short-Form Test of Academic Aptitude attempts to measure both language (verbal)

13 This name was chosen to preserve the anonymity of the Board.

and nonlanguage (nonverbal) mental ability in four areas: vocabulary development, logical reasoning, education of quantitative relations, and meaningful memory. Administered to various grades, SFTAA really is just an index of academic aptitude which "was developed as an instrument to assess the level of intellectual development attained by the student."[14] Hence, while the STEP attempts to evaluate the growth and rate of growth of development (achievement), SFTAA measures the actual level of development (intelligence). Data on the print-outs were converted into machine-readable form using the Optical Character Recognition technique so that eventually we obtained a STEP file of 3,041 pupil achievement scores and one file of 2,956 SFTAA scores.

With four different sources of data, namely, pupil scores and age, teacher data, school resource data, and socio-economic data, our purpose was then to incorporate them all into one file. The grade seven pupil in the Fernandez School Board during the 1972-73 school year was our selected unit of observation. The first match involved the 3,041 pupils on the STEP file and the 2,956 pupils on the SFTAA file. Using a search procedure which locates a key (pupil's name) in both files, the most we could possibly have hoped for in the output file would have been 2,956 entries. As it turned out we ended up with 2,526 observations, a loss of some 400 pupils.

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14 *Examiners Manual, Level 2, Short-Form Test of Academic Aptitude* (CTB/McGraw-Hill, Del Monte Research Park, Monterey, California), p. 5.

As well as containing the pupil scores and age, the SFTAA-STEP combined file was identified by the teacher name and a unique school number which made the next two matches easy. Using the teacher name and school number as the keys, we merged the pupil scores with selected teacher information on 99 grade seven teachers. Then, using the school number as the key we matched the combined file on pupil scores and teacher information with selected school resource information on the 17 appropriate schools in the Fernandez School Board from their Principal's Report. In this way, we obtained observations for 2,526 grade seven students who belonged to 99 different classes in 17 Fernandez schools. Each record contained student scores, student age, and details of teachers' background and school resources.

Five additional modifications were made before these data were used in our analysis. First, peers' averages were computed from the original SFTAA and STEP files, with each individual pupil's score being omitted from one calculation, so to isolate the impact the whole class has his own performance. In addition, the mean class age was also determined. These averages were added to the file.

Second, a count was made in our file for the individual class enrolments, which were summed over all the classes to compute the total enrolment in grade seven for each school. As a check, we looked at the corresponding figures derived from the Principal's Reports on School Resources. A comparison between these two counts is made in Table 1. As can be seen, there is quite a large discrepancy and using the counts on our file would not have been an accurate representation of the class sizes. Furthermore, since the total enrolment for grade seven in these 17 schools approximated the 3,050 or so achievement scores in the original STEP file (and any difference can be accounted for by the illegibility of original printouts) we felt justified in dividing up the Principal's Report figure into classes in the same proportion as the class sizes on our file, and using these adjusted figures.

Table 1

GRADE SEVEN ENROLMENT BY SCHOOL --
COMPARISON BETWEEN THE FIGURES FROM THE PRINCIPAL'S REPORT
AND THE ACTUAL COUNT ON OUR FILE

School Code	Principal's Reports	Our File
24	181	132
66	194	168
2	206	158
52	320	262
38	384	298
60	186	156
30	100	91
21	129	71
72	154	93
77	148	117
33	326	274
19	60	50
16	168	132
11	117	92
76	119	93
51	194	148
47	218	191
Total	3,204	2,526

Third, as a proxy for a measure of wealth of the community served by the school, we chose average income per household. The data available to us from Statistics Canada was a census tape with the unit of observation being census tracts in metropolitan areas. Since it can reasonably be argued that census tracts approximate the districts surrounding the school in population, and since we knew the addresses of these 17 schools, it was not very difficult to link average household income to the students. We chose to use this as a socio-economic variable possibly influencing the child's educational achievement. For scaling reasons, the income figure used was in hundreds of dollars.

Fourth, each class was not administered the full battery of achievement tests in reading, writing, science, and mathematics. In order to explain achievement it was necessary to divide up our data file into four separate files according to whether a student wrote the test in the subject area of the file. This meant, of course, that the four files were not mutually exclusive, that a student who had written more than one test appeared in more than one file. Each file was formatted exactly the same as the main file. There were 2,035 students who wrote the reading test, 1,739 who wrote the writing test, 1,291 who wrote the science test, and 2,477 in the mathematics file. (For purposes of expository simplicity, we only report estimates based on the reading and writing files in the next section of this report.)[15]

The final modification represented qualitative variables by sets of dummy variables. This dichotomization, which is described at length by Henderson, Mieszkowski and Sauvageau

15 Certain initial efforts were made to obtain reliable estimates for the relative importance of various factors affecting achievement in science and mathematics. These preliminary results were not adequate, and further efforts aimed at upgrading the data set and additional analytical work are indicated.

increases the number of determining variables that enter explicitly in the regression equation with an attendant loss of degrees of freedom but it permits the approximate modeling of non-linear features of the relationship between inputs and outputs.

All variables that were available for use after this matching process in our analysis of pupil's educational achievement in the Fernandez School Board are listed in Appendix 2. The final appendix lists the means and standard deviations of those particular variables included in the regression equations for reading and writing that are considered below.

Empirical Results

Least-squares estimates of coefficients in regression equations linking average achievement in writing and reading by individual pupils with possible inputs are presented in Tables 2 and 3, respectively. Each estimate is accompanied by a Fisher's F-statistic for the hypothesis that the coefficient being estimated has a zero value. It is assumed that the distribution of the error terms for the equations approximately fulfils the assumptions of the classical linear regression model, including normality[16]. Four distinct equations employing different groupings of variables are considered in each table. For tabular simplicity,

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16 These assumptions are listed in Chapter 1 of *Econometric Estimation* by J.C.R. Rowley (London: George Weidenfeld and Nicholson, 1973). Since test scores are polytomous, it has been recognized that these assumptions cannot hold exactly and that their acceptance may be inappropriate. This latter view is expressed by M. Nerlove and S. J. Press in *Univariate and Multivariate Log-Linear and Logistic Models* (Santa Monica, California: The Rand Corporation, 1971).

some of the estimated coefficients are not displayed in the tables even though they were calculated for certain of the fitted specifications. The variables represented by these coefficients generally had little impact on achievement.

From the entries in the tables, it appears that language IQ[17] and peer group effects (as represented by mean class scores) are significant factors in determining achievement in these two subject areas. The results with respect to the importance of peer group effects are broadly consistent with the findings in the work by Greenberg, and by Henderson, Mieszkowski and Sauvageau. Estimates for the coefficient of the variable recording the mean arithmetic scores of classes are sufficiently high to indicate that peer influences may be active through the *general* achievement levels of peers rather than solely through their achievement in specific subject areas. Our estimates, however, do not suggest much complimentarity between reading and writing achievement in this regard. The age of pupils is always associated with negative estimates. Our F-statistics suggest that the attendant coefficients are significantly different from zero so that age has a depressing impact on achievement when the influences of other factors are recognized.

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17 See Appendix 1 for an alternate specification using student's own *total* IQ instead of own language IQ.

Table 2

LEAST-SQUARES ESTIMATES OF REGRESSION COEFFICIENTS:

WRITING

(Sample size = 1739)

	Equation 1		Equation 2		Equation 3		Equation 4	
	Coefficient	F	Coefficient	F	Coefficient	F	Coefficient	F
Age of student	-0.222	(51.63)	-0.221	(49.86)	-0.228	(51.81)	-0.231	(53.01)
IQ	0.072	(84.70)	0.073	(84.97)	0.073	(86.02)	0.073	(86.03)
Mean reading score in class	--	--	--	--	0.090	(0.88)	-0.008	(0.01)
Mean writing score in class	0.584	(120.40)	0.584	(108.04)	0.385	(12.23)	0.315	(7.23)
Mean arithmetic score in class	--	--	--	--	--	--	0.275	(2.95)
Class size (I): less than 23	-4.455	(8.85)	-4.640	(7.97)	-3.279	(3.19)	-3.488	(3.60)
Class size (III): 28-35	1.037	(2.16)	1.323	(3.18)	0.979	(1.37)	1.072	(1.63)
Class size (IV): 36-42	0.618	(0.53)	0.854	(0.93)	1.428	(2.02)	1.539	(2.33)
Class size (V): more than 42	3.230	(5.22)	3.355	(5.21)	5.959	(9.19)	7.361	(11.97)
Age of teacher (I): less than 25	--	--	0.367	(0.24)	--	--	--	--
Age of teacher (II): 35-44	--	--	-0.908	(1.92)	--	--	--	--
Age of teacher (III): more than 44	--	--	0.539	(0.15)	--	--	--	--
Female teachers	--	--	0.103	(0.05)	--	--	--	--
Teacher's experience (I): 1-2 years	0.078	(0.02)	0.080	(0.02)	0.137	(0.04)	0.089	(0.02)
Teacher's experience (III): 6-7 years	1.562	(6.64)	1.693	(7.34)	1.367	(2.82)	1.215	(2.21)
Teacher's experience (IV): more than 7 years	1.080	(3.36)	1.172	(3.04)	1.415	(2.70)	0.867	(0.89)
No open space teaching	-0.455	(0.83)	-0.503	(0.88)	-1.565	(2.14)	-1.181	(1.17)
Largely open space teaching	--	--	--	--	-2.349	(2.03)	-3.977	(4.37)
Continuous progress[1] (I): not at all	--	--	--	--	-1.979	(0.60)	-2.223	(0.75)
Continuous progress (III): large extent	--	--	--	--	-2.561	(0.95)	-3.013	(1.31)
Continuous progress (IV): full	--	--	--	--	-6.495	(3.87)	-6.917	(4.37)
PTA	-3.014	(8.91)	-3.101	(9.01)	-5.293	(10.73)	-5.735	(12.30)
Number of television sets in school	--	--	--	--	0.959	(4.31)	1.261	(6.51)
Number of gymnasia	--	--	--	--	-2.207	(1.18)	-2.731	(1.77)
Student density in school	0.155	(5.59)	0.146	(3.86)	--	--	--	--
Mean household income	0.026	(11.07)	0.026	(9.06)	-0.005	(0.04)	-0.023	(0.71)
Constant	36.96		26.63		64.25		76.60	
R^2	0.275		0.276		0.283		0.284	

1 Continuous progress teaching is a form of instruction that is often adopted by all or part of a school; it involves allowing students to progress at their own rate: the conventional correspondence between school year and grade level is not present.

Table 3

LEAST-SQUARES ESTIMATES OF REGRESSION COEFFICIENTS:
READING
(Sample size = 2035)

	Equation 5		Equation 6		Equation 7		Equation 8	
	Coefficient	F	Coefficient	F	Coefficient	F	Coefficient	F
Age of student	-0.239	(45.94)	-0.239	(44.76)	-0.239	(45.07)	-0.241	(46.16)
IQ	0.129	(196.01)	0.129	(196.46)	0.129	(143.00)	0.128	(192.09)
Mean reading score in class	0.506	(135.73)	0.491	(89.13)	0.491	(50.57)	0.192	(3.80)
Mean writing score in class	--	--	--	--	-0.028	(0.19)	--	--
Mean arithmetic score in class	--	--	--	--	--	--	0.593	(15.25)
Class size (I): less than 23	-4.502	(6.75)	-4.459	(5.12)	-2.477	(1.33)	-2.606	(1.49)
Class size (III): 28-35	0.809	(1.09)	1.068	(1.71)	1.258	(1.95)	1.766	(3.78)
Class size (IV): 36-42	0.813	(0.79)	0.763	(0.64)	1.567	(2.11)	1.449	(1.82)
Class size (V): more than 42	3.310	(4.10)	3.551	(4.22)	2.979	(2.54)	4.506	(5.69)
Age of teacher (I): less than 25	--	--	0.675	(0.73)	--	--	--	--
Age of teacher (II): 35-44	--	--	-0.234	(0.10)	--	--	--	--
Age of teacher (III): more than 44	--	--	0.570	(0.13)	--	--	--	--
Female teachers	--	--	0.168	(0.11)	--	--	--	--
Teacher's experience (I): 1-2 years	0.464	(0.69)	0.330	(0.32)	0.276	(0.17)	0.189	(0.08)
Teacher's experience (III): 6-7 years	0.893	(1.61)	1.031	(2.01)	0.797	(0.79)	0.663	(0.54)
Teacher's experience (IV): more than 7 years	1.235	(3.55)	1.245	(2.82)	1.657	(3.08)	0.445	(0.21)
No open space teaching	--	--	0.234	(0.18)	-0.960	(0.64)	0.017	(0.00)
Largely open space teaching	--	--	--	--	0.770	(0.04)	-1.088	(0.84)
Continuous progress (I): not at all	--	--	--	--	-3.365	(1.54)	-1.630	(0.35)
Continuous progress (III): large extent	--	--	--	--	-0.557	(0.04)	0.689	(0.06)
Continuous progress (IV): full	--	--	--	--	-2.665	(0.54)	-0.521	(0.03)
PTA	-3.215	(7.99)	-3.351	(8.00)	-4.544	(5.77)	-4.958	(10.42)
Number of television sets in school	--	--	--	--	-0.013	(0.03)	0.032	(0.43)
Number of gymnasia	--	--	--	--	-1.763	(0.68)	-1.342	(2.43)
Student density in school	0.066	(1.39)	0.052	(0.60)	--	--	--	--
Mean household income	0.008	(0.94)	0.003	(0.12)	0.015	(0.35)	0.009	(0.14)
Constant	41.12		39.99		30.41		42.19	
R^2	0.283		0.284		0.293		0.299	

When a variable is represented in dichotomous form, one of the constituent dummy variables must be omitted to overcome the problem of exact multicollinearity. The coefficients of non-omitted variables should then be treated as differentials relative to the coefficient of the omitted variable. For example, with respect to class size, five dummy variables were created and that variable associated with classes of between 23 and 27 pupils was omitted. Our estimates of the coefficients for the non-omitted dummy variables should, therefore, be interpreted as indicators of net effects of class size relative to the basis of classes with between 23 and 27 pupils. The negative estimates recorded in Tables 2 and 3 for coefficients of class size category (I) probably reflect the special arrangements for so-called slow learners and they need not imply that a reduction in class size below 23 pupils leads to a reduction in achievement. However, the implications of other estimates associated with class size may not be so easily dismissed as attributable to special arrangements that are not directly reflected in our equations. Our estimates suggest that class size is positively related to achievement in writing and reading among grade seven students. This finding is clearly contrary to the commonplace assertion that smaller classes are desirable since achievement depends upon the "personal attention" accorded to each pupil which increases as class size decreases.

Turning to the attributes of teachers, it appears that neither their age nor their sex markedly affects the achievements of their charges in writing and reading. Their years of experience, however, are apparently important with teachers having six or more years of experience generally being associated with much higher levels of achievement than their less-experienced colleagues.

Our evidence concerning the impacts of school resources are somewhat mixed but it seems that neither open space nor continuous progress teaching arrangements have consistent impacts on achievement in both subjects. A large commitment to open space teaching may be to the detriment of achievement in writing but may not be so in reading. Similarly, a complete adoption of any continuous progress arrangement may have an adverse impact on writing achievement but our results do not indicate that this impact is also present for reading. It should be recalled that our standard unit of observation is the pupil in grade seven so that these particular results are not necessarily general for all grades. The two organizational forms could enjoy greater success at other levels in our schools and our data would be incapable of displaying this success. With respect to the provision of equipment, television sets in the school seem to stimulate writing but leave reading relatively unaffected. The role of facilities for physical education is ambiguous and we shall return to it below after further results are presented.

Differences between the estimated coefficients for the two subject areas again emerge with respect to student densities in schools and mean household incomes of census tracts that contain the schools. Both variables have significantly positive impacts on achievement in writing without displaying here any relevance for reading. (A qualification with respect to student densities and reading will be introduced in Appendix 1.) Our final estimates refer to the presence of parent-teacher associations. These estimates are always negative and F-statistics suggest that attendant coefficients are significantly less than zero.

Our description of procedures for matching and merging micro data revealed some of the problems experienced in the retention of individual files. If data omissions are not purely random, our estimates could be markedly affected by biases. After our primary estimates (those contained in Tables 2 and 3) were calculated, we sought to check their sensitivity to data changes by sub-sample validation techniques. Thus equations 3, 4, 7 and 8 were re-estimated after the data had been partitioned into two arbitrary sub-samples by alternatively assigning students as they were drawn from the main sample. Some of these additional estimates are presented in Tables 4 and 5. Again, for tabular simplicity, certain of the estimated coefficients are not displayed in the tables even though they were calculated for the fitted specifications. In particular, we omitted some of the variables that seemed to have little impact on achievement according to the magnitudes of both the initial estimates and the additional ones. To identify the two sub-samples, equation numbers are supplemented by symbols A and B in Tables 4 and 5.

Table 4

SENSITIVITY OF ESTIMATES TO CHANGES IN SAMPLE SIZE:
WRITING

	Equation 3A		Equation 4A		Equation 3B		Equation 4B	
	Coefficient	F	Coefficient	F	Coefficient	F	Coefficient	F
Age of student	-0.056	(1.76)	-0.057	(1.84)	-0.209	(19.83)	-0.214	(20.69)
IQ	0.376	(241.38)	0.376	(241.17)	0.044	(27.26)	0.044	(27.27)
Mean reading score in class	0.177	(2.04)	0.106	(0.54)	0.058	(0.18)	-0.061	(0.15)
Mean writing score in class	0.140	(0.96)	0.089	(0.34)	0.391	(6.10)	0.307	(3.33)
Mean arithmetic score in class	--	--	0.201	(0.96)	--	--	0.335	(2.10)
Class size (I): less than 23	-2.253	(0.90)	-2.417	(1.03)	-3.360	(1.64)	-3.601	(1.88)
Class size (III): 28-35	0.618	(0.34)	0.679	(0.41)	0.733	(0.36)	0.856	(0.49)
Class size (IV): 36-42	1.585	(1.51)	1.669	(1.67)	1.870	(1.66)	1.998	(1.89)
Class size (V): more than 42	4.035	(2.56)	5.050	(3.43)	8.087	(8.17)	9.804	(10.22)
Teacher's experience (I): 1-2 years	1.071	(1.56)	1.038	(1.46)	-0.276	(0.08)	-0.335	(0.12)
Teacher's experience (III): 6-7 years	1.356	(1.68)	1.256	(1.43)	0.663	(0.32)	0.463	(0.15)
Teacher's experience (IV): more than 7 years	2.013	(3.30)	1.613	(1.86)	-0.014	(0.00)	-0.680	(0.27)
No open space teaching	-1.903	(1.95)	-1.624	(1.36)	-1.434	(0.86)	-0.959	(0.37)
Largely open space teaching	-1.684	(0.63)	-2.879	(1.39)	-4.115	(3.00)	-6.083	(4.95)
Continuous progress (I): not at all	-6.038	(3.33)	-6.198	(3.50)	-3.000	(0.66)	-3.316	(0.81)
Continuous progress (II): large extent	-7.137	(4.42)	-7.458	(4.79)	-2.904	(0.59)	-3.460	(0.83)
Continuous progress (III): full	-11.459	(7.22)	-11.761	(7.55)	-7.070	(2.22)	-7.580	(2.54)
PTA	-5.476	(6.91)	-5.790	(7.55)	-5.799	(6.26)	-6.349	(7.32)
Number of television sets in school	0.452	(0.58)	0.674	(1.12)	1.204	(3.28)	1.571	(4.88)
Number of gymnasia	-4.146	(2.51)	-4.510	(2.91)	-4.312	(2.17)	-4.975	(2.82)
Constant	-12.60		-3.28		56.57		71.15	
R^2	0.441		0.441		--		0.262	

Table 5

SENSITIVITY OF ESTIMATES TO CHANGES IN SAMPLE SIZE:

READING

	Equation 7A		Equation 8A		Equation 7B		Equation 8B	
	Coefficient	F	Coefficient	F	Coefficient	F	Coefficient	F
Age of student	-0.347	(44.13)	-0.345	(43.96)	0.085	(3.76)	0.080	(3.36)
IQ	0.074	(53.19)	0.074	(52.87)	0.530	(542.14)	0.528	(540.40)
Mean reading score in class	0.506	(25.65)	0.185	(1.68)	0.357	(18.72)	0.140	(1.44)
Mean writing score in class	-0.069	(0.53)	--	--	0.066	(0.01)	--	--
Mean arithmetic score in class	--	--	0.604	(7.46)	--	--	0.453	(6.33)
Class size (I): less than 23	-4.614	(2.11)	-4.837	(2.34)	1.150	(0.21)	1.097	(0.19)
Class size (III): 28-35	1.008	(0.60)	1.538	(1.38)	1.370	(1.61)	1.749	(2.60)
Class size (IV): 36-42	1.052	(0.45)	0.958	(0.38)	1.995	(2.42)	1.588	(2.18)
Class size (V): more than 42	2.996	(1.23)	4.457	(2.65)	3.533	(2.53)	4.760	(4.51)
Teacher's experience (I): 1-2 years	-0.010	(0.00)	-0.046	(0.00)	0.961	(1.45)	0.856	(1.16)
Teacher's experience (III): 6-7 years	3.739	(8.28)	3.608	(7.76)	-1.337	(1.56)	-1.444	(1.83)
Teacher's experience (IV): more than 7 years	1.542	(1.27)	0.222	(0.03)	0.640	(0.33)	-0.219	(0.04)
No open space teaching	-2.042	(1.39)	-0.585	(0.20)	-0.634	(0.20)	-0.219	(0.04)
Largely open space teaching	0.497	(0.60)	-1.428	(0.69)	-1.370	(0.66)	-2.014	(2.04)
Continuous progress (I): not at all	-3.797	(0.93)	-2.109	(0.28)	-5.554	(2.96)	-4.147	(1.61)
Continuous progress (II): large extent	-0.506	(0.02)	0.808	(0.38)	-3.312	(0.94)	-2.362	(0.48)
Continuous progress (III): full	-2.830	(0.29)	0.149	(0.00)	-6.312	(2.16)	-5.206	(1.74)
PTA	-5.143	(3.52)	-4.945	(4.92)	-3.863	(2.96)	-4.608	(6.36)
Number of television sets in school	-0.090	(0.73)	-0.014	(0.03)	0.031	(0.13)	0.044	(0.43)
Number of gymnasia	-0.832	(0.07)	-0.781	(0.07)	-3.071	(1.47)	-2.468	(1.02)
Constant	28.88		33.91		30.24		-27.99	
R^2	0.284		0.289		0.502		0.505	

Some of the changes are disconcerting. For achievement in both writing and reading, the impact of peer groups becomes notably less precise with reduced samples although there remains sufficient evidence to affirm that some positive impact is present. The negative influence of age on achievement noted in the full sample often persists in sub-samples but it is less pronounced, and for reading, a reversal of sign is indicated by the estimates for equations 7B and 8B (but not for equations 7A and 8A). Our additional estimates for the coefficient of language IQ also exhibit considerable numerical variability although the coefficient remains highly significant according to the values of the corresponding F-statistics.

The positive relation between class size and achievement that was identified earlier receives further confirmation from the additional estimates. Unfortunately, we cannot find firm confirmation for the inference that teachers with six or more years of experience have generally been associated with higher levels of achievement than their less-experienced colleages. Values of estimates calculated using the two sub-samples are markedly different so the impact of teacher's experience clearly needs more exploration.

Turning again to the impacts of school resources, the patterns of earlier estimates are often repeated. Thus largely open space teaching apparently deters achievement in writing but probably not achievement in reading. Similarly continuous progress teaching arrangements may adversely affect writing and television may stimulate it without having the same impacts on reading for grade seven students. The additional estimates indicate a pronounced adverse impact on achievement in writing associated with increases of facilities for physical education that was not apparent in earlier estimates. Both sets of estimates are negative but the magnitudes of those based on the sub-samples are about twice the size of the others.

In conclusion, our new set of micro data is consistent in an educational production-function framework with a number of stable inferences concerning various influences on achievement in writing and reading. However, further exploration is indicated with respect to certain other influences by the lack of robustness experienced in some estimates. It can be confirmed from the entries in Appendix 1 that the use of total IQ instead of language IQ does not markedly affect most of the conclusions that we have drawn above, although the relative magnitudes of estimates change due to the predominant impact accorded to total IQ after this respecification.

Appendix 1

AN ALTERNATIVE MEASURE OF INTELLIGENCE

Here, we are investigating the sensitivity of our estimates to a change in the measure of intelligence. We had at our disposal (see Appendix 2) three measures of intelligence: the language IQ which relates specifically to school-oriented tasks and which we have already used, the non-language IQ which is likely less sensitive to cultural influences, and total IQ which is a derived combination and *not* a simple arithmetic average of the other two IQ's. In this appendix, we opt for the latter as a good general measure of intelligence.

It can be confirmed from the entries in these four tables (Tables 6 though 9 correspond to Tables 2 through 5 in the main body of the text) that the new measure does not markedly affect the basic conclusions we have drawn above. Although intelligence exerts an even greater influence upon achievement that it did before, this predominance, however, does change the relative magnitudes of the estimates; one notable change was in student density, or students per acre, which earlier did not seem to affect achievement but which now does, significantly and positively.

Table 6

LEAST-SQUARES ESTIMATES OF REGRESSION COEFFICIENTS:
WRITING WITH TOTAL IQ REPLACING LANGUAGE IQ

	Equation 1		Equation 2		Equation 3		Equation 4	
	Coefficient	F	Coefficient	F	Coefficient	F	Coefficient	F
Age of student	-0.089	(8.73)	-0.092	(9.25)	-0.101	(11.01)	-0.102	(11.33)
Own total IQ	0.265	(344.80)	0.268	(349.94)	0.276	(366.64)	0.276	(367.55)
Mean total IQ in class	--	--	--	--	0.170	(6.32)	0.142	(4.17)
Mean reading score in class	--	--	--	--	-0.022	(0.06)	-0.101	(0.98)
Mean writing score in class	0.431	(55.80)	0.450	(53.54)	0.197	(3.30)	0.150	(1.77)
Mean arithmetic score in class	--	--	--	--	--	--	0.243	(2.53)
Class size (I): less than 23	-3.892	(7.44)	-3.948	(6.32)	-1.576	(0.80)	-1.947	(1.19)
Class size (III): 28-35	0.883	(1.79)	1.309	(3.59)	0.735	(0.89)	0.844	(1.16)
Class size (IV): 36-42	0.020	(0.00)	0.337	(0.17)	1.238	(1.80)	1.360	(2.16)
Class size (V): more than 42	3.064	(5.38)	3.286	(5.86)	7.157	(15.658)	8.370	(11.20)
Age of teacher (I): less than 25	--	--	0.848	(1.49)	1.146	(2.26)	1.150	(2.28)
Age of teacher (II): 35-44	--	--	-0.515	(0.76)	1.162	(0.06)	0.337	(0.24)
Age of teacher (III): more than 44	--	--	0.565	(0.19)	-0.669	(0.18)	-0.444	(0.08)
Teacher's sex	--	--	0.465	(1.16)	--	--	--	--
Teacher's experience (I): 1-2 years	-0.053	(0.01)	-0.085	(0.03)	-0.003	(0.00)	-0.016	(0.00)
Teacher's experience (III): 6-7 years	0.885	(2.39)	1.104	(3.59)	0.211	(0.07)	0.149	(0.04)
Teacher's experience (IV): more than 7 years	0.481	(0.74)	0.515	(0.67)	0.637	(0.64)	0.187	(0.05)
No open space teaching	-0.502	(1.17)	-0.644	(1.72)	-2.479	(5.98)	-2.062	(3.89)
Largely open space teaching	--	--	--	--	-3.289	(4.62)	-4.791	(7.10)
Continuous progress (I): not at all	--	--	--	--	-5.391	(5.29)	-5.483	(5.48)
Continuous progress (III): large extent	--	--	--	--	-6.900	(7.87)	7.101	(8.33)
Continuous progress (IV): full	--	--	--	--	-13.501	(16.90)	13.437	(16.75)
PTA	-2.380	(6.14)	-2.402	(6.06)	-6.754	(19.30)	-7.010	(20.59)
Number of television sets in school	--	--	--	--	0.833	(3.72)	1.123	(5.74)
Number of gymnasia	--	--	--	--	-5.527	(8.57)	-5.852	(9.60)
Student density in school	0.181	(8.75)	0.180	(6.84)	0.324	(3.01)	0.231	(1.39)
Mean household income	0.013	(2.58)	0.011	(1.49)	-0.047	(4.24)	-0.062	(6.23)
Constant	-0.649		-24.391		32.192		42.552	
R^2	0.366		0.369		0.381		0.382	

Table 7

LEAST-SQUARES ESTIMATES OF REGRESSION COEFFICIENTS:
READING WITH TOTAL IQ REPLACING LANGUAGE IQ

	Equation 5		Equation 6		Equation 7		Equation 8	
	Coefficient	F	Coefficient	F	Coefficient	F	Coefficient	F
Age of student	-0.075	(4.99)	-0.081	(5.71)	-0.087	(6.56)	-0.085	(6.27)
Own total IQ	0.370	(585.02)	0.371	(580.67)	0.372	(579.94)	0.371	(579.40)
Mean total IQ in class	--	--	0.004	(2.22)	0.159	(5.41)	0.058	(0.73)
Mean reading score in class	0.402	(99.01)	0.363	(47.54)	0.267	(13.34)	0.027	(0.08)
Mean writing score in class	--	--	--	--	-0.096	(2.51)	--	--
Mean arithmetic score in class	--	--	--	--	--	--	0.533	(13.77)
Class size (I): less than 23	-3.794	(5.63)	-3.345	(3.30)	-1.117	(0.30)	-1.906	(0.90)
Class size (III): 28-35	0.672	(0.88)	1.02	(1.86)	1.115	(1.79)	1.640	(3.79)
Class size (IV): 36-42	-0.056	(0.00)	-3.363	(0.17)	0.397	(0.16)	0.518	(0.27)
Class size (V): more than 42	3.223	(4.60)	3.672	(5.50)	4.549	(7.03)	5.426	(9.90)
Age of teacher (I): less than 25	--	--	--	--	--	--	--	--
Age of teacher (II): 35-44	--	--	--	--	--	--	--	--
Age of teacher (III): more than 44	--	--	--	--	--	--	--	--
Teacher's sex	--	--	0.800	(2.84)	1.289	(5.16)	1.746	(9.45)
Teacher's experience (I): 1-2 years	0.048	(0.01)	0.541	(0.12)	-0.297	(0.23)	-0.165	(0.07)
Teacher's experience (III): 6-7 years	0.006	(0.00)	0.665	(0.04)	-0.394	(0.22)	-0.264	(0.10)
Teacher's experience (IV): more than 7 years	0.228	(0.14)	0.700	(0.06)	0.151	(0.03)	-0.833	(0.86)
No open space teaching	--	--	0.502	(0.20)	-2.164	(3.60)	-0.305	(0.13)
Largely open space teaching	--	--	--	--	0.457	(0.12)	-1.701	(2.49)
Continuous progress (I): not at all	--	--	--	--	-3.805	(2.39)	-2.307	(0.86)
Continuous progress (III): large extent	--	--	--	--	-2.068	(0.62)	-0.590	(0.05)
Continuous progress (IV): full	--	--	--	--	-7.812	(4.97)	-3.407	(1.18)
PTA	-2.378	(5.13)	1.10	(4.40)	-6.098	(11.70)	-5.067	(12.87)
Number of television sets in school	--	--	--	--	-0.116	(2.65)	-0.010	(0.04)
Number of gymnasia	--	--	--	--	-2.605	(1.81)	-2.578	(1.86)
Student density	0.110	(4.48)	0.062	(2.37)	0.482	(5.59)	0.219	(5.84)
Mean household income	-0.000	(0.00)	-0.013	(1.98)	-0.003	(0.02)	-0.011	(0.26)
Constant	-3.491		-8.509		15.002		13.20	
R^2	0.390		0.393		0.401		0.404	

Table 8

SENSITIVITY OF ESTIMATES TO CHANGES IN SAMPLE SIZE:
WRITING WITH TOTAL IQ REPLACING LANGUAGE IQ

	Equation 3A		Equation 4A		Equation 3B		Equation 4B	
	Coefficient	F	Coefficient	F	Coefficient	F	Coefficient	F
Age of student	-0.131	(9.30)	-0.131	(9.35)	-0.054	(1.50)	-0.057	(1.67)
Own total IQ	0.268	(158.95)	0.268	(159.02)	0.284	(199.92)	0.284	(200.60)
Mean total IQ in class	0.167	(2.96)	0.145	(2.08)	0.158	(2.77)	-0.195	(0.69)
Mean reading score in class	0.053	(0.17)	-0.008	(0.00)	-0.082	(0.43)	-0.181	(1.56)
Mean writing score in class	0.138	(0.78)	0.101	(0.39)	0.264	(3.01)	0.207	(1.71)
Mean arithmetic score in class	--	--	0.189	(0.74)	--	--	0.297	(1.90)
Class size (I): less than 23	-1.757	(0.48)	-2.055	(0.64)	-1.403	(0.32)	-1.842	(0.55)
Class size (III): 28-35	0.805	(0.53)	0.883	(0.63)	0.673	(0.37)	0.817	(0.53)
Class size (IV): 36-42	1.170	(0.79)	1.268	(0.92)	1.267	(0.94)	1.410	(1.16)
Class size (V): more than 42	5.161	(3.96)	6.088	(4.70)	8.926	(12.30)	10.422	(14.20)
Teacher's sex	--	--	--	--	--	--	--	--
Teacher's experience (I): 1-2 years	0.634	(0.52)	0.618	(0.49)	-0.675	(0.60)	-0.707	(0.65)
Teacher's experience (III): 6-7 years	0.778	(0.48)	0.742	(0.44)	-0.364	(0.11)	-0.456	(0.17)
Teacher's experience (IV): more than 7 years	1.879	(2.70)	1.530	(1.59)	-0.613	(0.30)	-1.161	(0.95)
No open space teaching	-2.440	(2.85)	-2.116	(2.01)	-2.499	(3.04)	-2.000	(1.81)
Largely open space teaching	-1.038	(0.23)	-2.204	(0.74)	-5.453	(6.36)	-7.284	(8.24)
Continuous progress (I): not at all	-5.311	(2.49)	-5.365	(2.54)	-5.312	(2.60)	-5.443	(2.73)
Continuous progress (III): large extent	-7.748	(4.80)	-7.897	(4.97)	-5.767	(2.80)	-6.021	(3.04)
Continuous progress (IV): full	-14.235	(9.02)	-14.171	(8.93)	-12.207	(7.02)	-12.137	(6.95)
PTA	-7.223	(10.66)	-7.416	(11.11)	-5.984	(7.67)	6.307	(8.43)
Number of television sets in school	0.464	(0.56)	0.610	(1.06)	1.149	(3.56)	1.504	(5.18)
Number of gymnasia	-5.005	(3.44)	-5.241	(3.73)	-5.791	(4.78)	-6.207	(5.43)
Student density in school	0.572	(4.62)	0.499	(3.19)	0.068	(0.07)	-0.044	(0.03)
Constant	34.915		43.179		25.772		38.080	
R^2	0.392		0.392		0.386		0.388	

Table 9

SENSITIVITY OF ESTIMATES TO CHANGES IN SAMPLE SIZE:
READING WITH TOTAL IQ REPLACING LANGUAGE IQ

	Equation 7A		Equation 8A		Equation 7B		Equation 8B	
	Coefficient	F	Coefficient	F	Coefficient	F	Coefficient	F
Age of student	-0.148	(8.88)	-0.141	(8.15)	-0.033	(0.49)	-0.034	(0.53)
Own total IQ	0.361	(273.35)	0.360	(272.88)	0.384	(299.80)	0.383	(300.10)
Mean total IQ in class	0.184	(3.53)	0.077	(0.62)	0.134	(1.94)	0.043	(0.21)
Mean reading score in class	0.281	(7.36)	0.045	(0.11)	0.262	(6.40)	0.030	(0.05)
Mean writing score in class	-0.137	(2.53)	--	--	-0.053	(0.38)	--	--
Mean arithmetic score in class	--	--	0.499	(5.91)	--	--	0.540	(7.18)
Class size (I): less than 23	-4.246	(2.08)	-5.163	(3.13)	1.894	(0.45)	1.250	(0.20)
Class size (III): 28-35	1.076	(0.83)	1.591	(1.76)	1.100	(0.87)	1.608	(1.83)
Class size (IV): 36-42	-0.074	(0.00)	0.091	(0.00)	0.786	(0.31)	0.858	(0.37)
Class size (V): more than 42	4.372	(3.21)	5.038	(4.19)	4.691	(3.77)	5.718	(5.58)
Teacher's sex	--	--	1.987	(5.98)	--	--	1.391	(3.04)
Teacher's experience (I): 1-2 years	-0.494	(0.31)	-0.291	(0.11)	-0.098	(0.01)	-0.038	(0.00)
Teacher's experience (III): 6-7 years	2.524	(4.45)	2.689	(5.12)	-3.324	(7.86)	-3.230	(7.65)
Teacher's experience (IV): more than 7 years	0.086	(0.00)	-0.906	(0.50)	0.195	(0.03)	-0.735	(0.34)
No open space teaching	-2.960	(3.45)	-0.632	(0.28)	-1.228	(0.58)	0.091	(0.01)
Largely open space teaching	0.843	(0.21)	1.822	(1.40)	0.118	(0.00)	-1.453	(0.92)
Continuous progress (I): not at all	-3.051	(0.75)	-1.692	(0.23)	-4.655	(1.81)	-3.065	(0.77)
Continuous progress (III): large extent	-0.618	(0.03)	0.899	(0.06)	-3.751	(1.03)	-2.345	(0.40)
Continuous progress (IV): full	-5.980	(1.42)	-0.703	(0.03)	-9.630	(3.83)	-6.223	(1.99)
PTA	-5.863	(5.32)	-4.090	(4.11)	-6.377	(6.44)	-6.075	(9.34)
Number of television sets in school	-0.200	(3.96)	-0.064	(0.74)	-0.022	(0.05)	0.048	(0.43)
Number of gymnasia	-1.084	(0.15)	-1.448	(0.29)	-4.319	(2.52)	-3.903	(2.16)
Student density in school	0.596	(4.23)	0.209	(2.63)	0.364	(1.58)	0.229	(3.22)
Constant	-5.536		-6.803		32.001		29.576	
R^2	0.413		0.415		0.408		0.412	

Appendix 2

VARIABLES AVAILABLE FOR USE IN ANALYSIS

Symbols C and D indicate whether the variables have continuous or dichotomous form.

Student Achievement Scores

C	Reading
C	Writing
C	Science
C	Arithmetic

Source: Fernandez STEP scores, February-March 1973.

Student Information

C	Student age in months
C	Language IQ
C	Nonlanguage IQ
C	Total IQ

Source: Fernandez SFTAA scores, October-November 1972.

Peer Group's Averages for Class

C	Mean age
C	Mean language IQ
C	Mean nonlanguage IQ
C	Mean total IQ
C	Mean reading score
C	Mean writing score
C	Mean science score
C	Mean arithmetic score

Source: Calculated from the above with single scores omitted.

School Resources

	Open-space teaching:
D	Not at all
D	To some extent
D	To a large extent
	Continuous progress teaching arrangements:[1]
D	Not at all
D	To some extent
D	To a large extent
D	Fully
	Existence of a PTA:
D	Yes
D	No

1 Continuous progress teaching represents a form of instruction whereby students are allowed to progress through grade levels when they have completed them (i.e., at their own pace).

C Total school enrolment
C Total grade seven enrolment
C Number of radios
C Number of television sets
C Number of videotape recorders
C Number of TV cameras
C Number of gymnasia
C Number of lunchrooms
C Size of site in acres
C Density or students per acre[2]

Source: Ontario Ministry of Education, Principals' Reports, 1972.

Teacher-Classroom Variables

C Class size by actual count
C Proportional class size
C Year of birth
Years of experience:
C Elementary
C Total
Proportional class size:
D Less than 22
D 23-27
D 28-35
D 36-42
D 43 or more
Age in years:
D Less than 21
D 25-34
D 35-44
D 45 or more
Sex:
D Male
D Female
Marital status:
D Unspecified
D Single
D Married, supported
Elementary years of experience:
D 1 or 2
D 3-5
D 6 or 7
D 7 or more
Total years of experience:
D 1 or 2
D 3-5
D 6-10
D 11-25
D 25 or more

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2 This variable is defined as total school enrolment divided by the size of school site in acres.

College degree:
D None
D Yes
Attended summer/winter courses:
D Yes
Teaching certificate:[3]
D None
D Standard I
D Standard II
D Standard III
D Standard IV
Special certificates:
D Guidance
D Mathematics
D Physical education

Source: Ontario Ministry of Education, 1972-73.

Socioeconomic Variables

C Average income per household (in hundreds of dollars)

Source: Statistics Canada, 1971 Census.

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3 The teaching certificates that used to be given to elementary school teachers is now an antiquated system in Ontario. The requirement for teaching is now a university degree. However, each standard does indicate the highest level of education previously attained by the teacher:

Standard I = grade 13
Standard II = five university credits (1 year)
Standard III = ten university credits (2 years)
Standard IV = fifteen university credits (degree).

Appendix 3

Table 10

MEANS AND STANDARD DEVIATIONS
OF THE VARIABLES USED IN THE REGRESSIONS

Variable	Reading File Mean	Reading File Standard Deviation	Writing File Mean	Writing File Standard Deviation
Student: Age in months	150.852	6.194	150.952	6.347
Language IQ	103.114	28.805	102.807	25.152
Total IQ	104.532	14.341	104.117	14.298
Average household income (in hundreds of dollars)	137.490	30.087	137.277	32.025
Peer's mean age	150.859	2.137	150.915	12.307
Peer's mean language IQ	102.702	7.930	102.382	8.531
Peer's total IQ	103.957	6.248	103.448	6.473
Peer's mean reading score	41.429	6.275	41.221	6.678
Peer's mean writing score	26.502	11.593	30.780	4.943
Peer's mean arithmetic score	24.594	3.745	24.436	3.949
School, Open space teaching:				
Not at all	.585	.493	.599	.490
To a large extent	.108	.310	.132	.338
Continuous progress teaching:				
Not at all	.065	.246	.073	.260
To a large extent	.658	.474	.610	.488
Fully	.073	.261	.086	.280
Existence of a PTA: Yes	.069	.253	.080	.271
Number of television sets	5.195	5.506	2.606	.951
Number of gymnasia	1.135	.342	3.950	.363
Density or students per acre	11.319	4.844	12.416	4.287
Teacher, Age in years:				
Less than 24	.129	.335	.100	.300
35-44	.123	.328	.117	.321
45 or more	.038	.192	.044	.204
Sex: Female	.583	.493	.586	.493
Elementary years of experience:				
1 or 2	.210	.407	.184	.389
6 or 7	.129	.335	.143	.360
8 or more	.153	.360	.167	.373
Attended summer/winter courses	.331	.471	.340	.474
Teaching certificate:				
None	.035	.183	.041	.197
Standard I	.369	.483	.340	.474
Standard II	.139	.346	.147	.355
Standard IV	.340	.474	.352	.479
Special certificates:				
Guidance	.065	.247	.061	.239
Physical education	.106	.307	.107	.310
Reading score	42.039	11.115	--	--
Writing score	--	--	31.656	9.146