A SIMULTANEOUS EQUATIONS MODEL OF THE EDUCATIONAL PROCESS: THE COLEMAN DATA REVISITED WITH AN EMPHASIS UPON ACHIEVEMENT*

Anthony E. Boardman, Otto A. Davis, Carnegie-Mellon University,
and Peggy R. Sanday, University of Pennsylvania

1. Introduction

The report, Equality of Educational Opportunity [6], the EEOR, acted as a watershed for research into educational production functions. Virtually all of the voluminous research in this area chooses verbal achievement as the sole achievement measure. Very few papers examine other measures such as non-verbal, reading or mathematical achievement.

With a single exception, Levin [12], no model of the educational process allows for feedback effects from one variable to another. Studies have found, for example, that a pupil's self concept and belief in his ability to control the environment are extremely important predictors for pupil achievement. But, as Mosteller and Moynihan point out in On Equality of Educational Opportunity, OEOEO [14], "could not such feelings of control be essentially a feedback reaction from reality? Bright students who got good marks might well feel good about themselves." Thus a model of the educational process should postulate pupil achievement and control of the environment as endogenous variables.

Our paper has two main purposes. First, it examines verbal, non-verbal, reading, mathematical and general informational achievement. Second, it estimates the achievement equations of a simultaneous equations model of the educational process.[1] The analysis may allow us to make important statements about the factors affecting different types of achievement.[2]

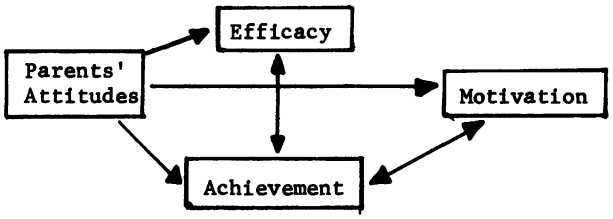
2. The Emphasis on Verbal Achievement

The EEOR [6] concentrated almost exclusively on verbal achievement.[3] Few reanalyses of the Equality of Educational Opportunity survey, EEOS, data consider any output other than verbal achievement. Mayeske, et al.[13], construct an index from the first component of a principal components analysis on verbal, non-verbal, reading, mathematical and general informational achievements. Boardman, et al. [3,4] derive a similar index. Most analyses consider only verbal achievement. In OEOEO [14], reanalyses by Jencks, Armor, Smith and Cohen, Pettigrew and Riley all use verbal achievement as the sole dependent variable.[4] Gordon [8] and Levin [12] also restrict attention to this achievement measure.

Many researchers have considered outputs other than verbal achievement. The list is too long to recite here, but Stafford [16], Aiken [1], and Dwyer [7] review many of them. One cannot really compare existing results or theories with this research for two reasons. First, previous research considers only a limited number of variables, sometimes only a single explanatory variable.[5] Second, prior studies do not use a simultaneous equations model.

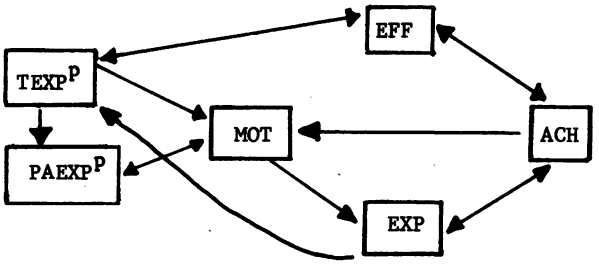
3. Simultaneous Equations Model of the Educational Process

Levin [12] should receive considerable credit for first publishing the notion of modeling the educational process by a system of simultaneous equations.[6] He estimated a model in which pupil achievement, motivation and efficacy, and parent's attitudes (expectations) interact thus:



More recently, Gordon [8] published a simply recursive model of the educational process with family structure, pupil's verbal ability, parental aspirations, and pupil's self-concept and aspirations as the endogenous variables. Because of Gordon's desire to use Path analysis rather than more sophisticated simultaneous equations techniques, the model does not allow any feedback effects. For this reason, Gordon's model represents a step backwards rather than a step forward from Levin's original formulation.

Boardman, et al. [3], extended Levin's work and successfully estimated a simultaneous equations model of the educational process with six endogenous variables. This model treats pupil achievement, ACH, motivation, MOT, expectations, EXP, and efficacy, EFF, and perceived parents' and teachers' expectations, $PAEXP^P$ and $TEXP^P$ [7], as endogenous variables. The following diagram represents the estimated relationships between the endogenous variables where the level of confidence exceeds 0.05 for all variables.



Of all the endogenous variables, only pupil efficacy and expectations appear to have a direct effect on pupil achievement; the other endogenous variables have important but indirect effects.

4. Description and Preliminary Analysis of the Achievement Tests

The Educational Testing Service, ETS, constructed the achievement tests and administered the questionnaires to the thousands of students in the EEOS. The verbal test consisted of thirty questions which asked for the "best" missing word of a sentence, and thirty questions on synonyms. The non-verbal test contained twenty-six questions on picking one figure from a group of five that had the least in common with the remaining four, and twenty-four questions on matching a given figure with one out of a group of five. The reading test required the students to read seven short passages (from articles, books, letters, sonnets or plays) and answer five questions per passage on content and tone. Twenty-five questions covered mathematics (simple computations and geometry). The last test consisted of ninety-five general informational questions that covered a wide range of interests and areas.[8] The ETS aimed to measure those "skills which are most important in our society for getting a good job and moving up to a better one, and for full participation in an increasingly technical world."[9] None of these tests were designed to measure intelligence.

Our first stage in the research consisted of performing a principal components analysis on the correlation matrix of the number of corrected answers to each test.[10] We obtained the following factor matrix:

Achievement Variable	Factor 1	Factor 2	Factor 3
Verbal	0.91447	-0.18853	0.14467
Non-verbal	0.79736	0.06406	-0.60147
Reading	0.88104	-0.29293	0.07729
Mathematical	0.77779	0.59325	0.17393
General Informational	0.89636	-0.09262	0.15909

Factor	Eigenvalue	Pct. of Var.
1	3.65667	73.1
2	0.48598	9.7
3	0.44422	8.9

Table I

The first component indicates that verbal achievement has most in common with the other achievement measures, while non-verbal achievement and mathematical achievement have least in common with the other achievement measures. The second and third components suggests that non-verbal and mathematical achievements have little in common with each other. This finding surprised us. In fact, both non-verbal and mathematical achievement correlate least with each other. The rapidly falling eigenvalues show that the first the first component explains most of the combined variance, while the other components add little. Basically, these tests measure a similar characteristic.[11]

5. Regional, Racial and Individual Findings for the Achievement Equations

In view of the above conclusion that the various tests probably measure the same characteristic, it is not at all surprising that the estimated results (reported in Appendix II[12] at the end of the paper) indicate that in general the same endogenous and exogenous variables explain each of the various tests. For example, efficacy, the endogenous variable which directly affects achievement, has positive and significant coefficients in the structural equations of all of the tests. Similarly, the coefficients for the average teachers' score are always positive, while those for the age of the student are always negative. Such general results may comfort those who have analyzed only one achievement measure.

The significance of the efficacy variable suggests that performance on all of these tests improves as the child increases his self-concept and belief in his ability to control the environment. These attitudes appear particularly important for general informational achievement. Of all the other endogenous variables, pupil expectations is the only one which enters the second stage achievement equations; it enters only the mathematical equation. The other endogenous variables, including motivation--a measure of hard work and attitude to work--fail to exert a direct effect.[13]

The coefficients for the dummy variables for the regions of the U. S. vary slightly across regions. The variables in the non-verbal achievement equation seem quite different from those in the verbal achievement equation, yet quite similar to those in the general informational equation. Some consistencies emerge clearly. Students from the Plains States seem to perform better than students from any other region while students from the South, both the Southeast and the Southwest, appear to do worse than students from the other regions. Perhaps the most striking finding is that these coefficients are relatively small in absolute value, while the difference between regional mean achievements are quite substantial.

Substantial differences exist in the average achievement scores across the ethnic groups (see Table II). American Indians, Mexican Americans, Blacks, and Puerto Ricans obtain on the average 12 to 14 fewer correct answers than Whites on the verbal achievement test. Oriental-Americans obtain on the average 2 fewer correct answers than Whites on this test. When we take other variables into account, by including them

in the regressions, the differences drops substantially. The structural form coefficients for Blacks and Whites differ by approximately 5 points in the verbal achievement equation, a drop of 9 points. [14] Similar patterns hold for the other minority groups except for Oriental Americans who have more positive structural form coefficients than Whites. The coefficients for American Indians and Whites differ by approximately 4 in the verbal achievement equation, a reduction of about 8 points. For Mexican Americans and Puerto Ricans the initial differences reduce to approximately 5 points. Hence while minority group status appears to be detrimental for four of these groups, the differentials are not nearly so substantial as might be suggested by a simple examination of the averages.

Pupils attending predominantly White schools (70%-100% White) perform better than pupils in partially integrated schools (30%-69% White) or mainly Black schools (0%-29% White). Except for verbal achievement, there appears to be negligible benefits in achievement from attending an integrated school as opposed to a non-majority school. These results suggest that if one wants to integrate to improve achievement, the integration should be complete. [15]

Average socio-economic class of peers is positive in all equations. This variable may reflect a peer group orientation to achievement. Eliot Richardson [16] said that children learn more from each other than from any other resource of the education environment. If this is the case then the values communicated among peers could have an important impact on a child's receptivity to learning. Average SES of the school could also reflect the general quality of the school, or something about the home background. When this variable is excluded from the regressions the school variables change more than the home variables. Hence one might infer that it reflects the school more than the home.

One reason for including the pupils' average socio-economic status stems from the criticism by educators and sociologists that one cannot reasonably consider teacher and school effects as exogenous with individual pupil data[17]. The argument claims that better pupils attract better teachers. Furthermore, those pupils of a higher socio-economic status may attend better schools because their parents can afford (may be required) to pay more per pupil to the school board. Thus, both the quality of the teachers and the schools may be superior in a higher socio-economic area. If one finds that school and teacher variables are important, it may be a result of better pupils, not better schools. Since this research controls for the average socio-economic status any observed teacher and school effects should not be spurious.[18]

The variable for sex is interesting. For verbal, non-verbal and mathematical achievement, as well as for general knowledge, the estimated coefficients are negative and very significant. These results indicate that males are better achievers across these individual cognitive dimensions. On the other hand, in the test for reading achievement, the estimated coefficient for sex is positive and significant, which indicates that on the average females are better at reading than are males. Apparently this phenomenon has been observed many time previously, and some sociologists and psychologists have attempted to explain it by saying that our society considers reading to be a feminine rather than a masculine activity. [19]

In regard to other individual characteristics, observe that age has a negative effect upon all measures of achievement. One may expect that schools hold back some underachieving students. In the twelfth grade, these pupils would be older yet still poorer performers. The more older brothers and sisters that a pupil has, the worse he does on all measures of achievment, with the exception of mathematical achievment. Interestingly home stability as measured by whether there are two parents alive and living at home seems important for non-verbal and mathematical achievements. Information in the home seems important for verbal and general informational achievements.

6. School Variables Which May Affect Achievement

Recent years have witnessed an increasing acceptance of the argument that variables associated with schools contribute little to educational outcomes.[20] Our results do not support this position. Even though our measures of school characteristics are crude and certainly not ideal, they do appear to have important effects on achievement. The best measure that can be obtained for the quality of a school's faculty, for example, is the average score of the teachers on a verbal achievement test. The coefficients for teachers' average verbal right in the structural equations for each achievement test is positive and exceptionally significant. Similarly, the number of teachers per pupil, often thought in some educational circles (but not among laymen) to be an irrelevant variable, is positively and significantly associated with each of the various measures of achievement.

Teachers' experience, measured by the aveage number of years teaching, appears to have a quadratic effect upon all measures of achievement except mathematical achievement. A simple interpretation of this effect is that in the first few years on the job, a teacher loses the initial excitement and enthusiasm and thus performs less well; but as years pass, experience begins to dominate and has an increasingly

positive effect upon achievement. One might also argue that natural selection occurs and dedicated teachers tend to be the ones who remain on the job to gain experience while those who really were not interested in this profession drop out.

The above results are highlighted and perhaps confounded by the fact that the number of teachers leaving is positively associated with achievement as it is measured on the verbal, non-verbal and reading tests. Also somewhat surprisingly, the perception on the part of teachers of the lack of effective administrative leadership is positively related to all measures of achievement. Since the mean of this variable is low, one might speculate that only the better and more perceptive teachers are able to recognize such problems and these teachers perform well in any event.

Schools which have a policy of administering achievement and IQ tests to their students also have pupils who score significantly higher on each of the various achievement tests. Even school facilities, generally thought to be irrelevant, appear to be positively associated with non-verbal and reading achievement. The age of the school is negatively associated with verbal and non-verbal achievement, but positively associated with reading achievement. Finally, problems in the school have negative effects on all achievement measures.

Unfortunately this body of data does not include variables which measure the degree of interaction between pupils and teachers in the classroom, nor does it include measures of teaching materials. In retrospect, we believe that we should have included a variable for the curriculum program. One rarely included all important variables in an estimation. We aim to perform further analyses on these rich data in later papers.

7. Concluding Remarks

These results do not allow us to say directly that the school is more important than the home for one type of achievement, but not for another type. Both the home and the school are important for all achievements, especially verbal and general informational. More variables seem important for non-verbal achievement than for any other type of achievement. The absolute value of the coefficients in the mathematical achievement equations are generally smaller than in the other equations. This finding and the lower R^2 indicated that the explanatory variables may be less important for mathematics than for other achievements. Perhaps mathematics requires a specific attitude or aptitude more than other subjects require a distinct attitude or aptitude. Contrary to the probably expectations of the EEOR's authors, the general informational equation fits the data best, not the verbal equation.

There are several other conclusions which require emphasis. First, of course, is the conclusion that the various tests really measure a common characteristic. Furthermore, an independent variable which affects one measure of achievement generally affects the others in the same direction and in roughly the same magnitude. This finding should offer comfort to those who have just used one measure of achievement in their analysis.

Relative to the omitted group (the surprisingly large number of American students who state that they do not know their race), Whites and Orientals perform best on all tests of achievement. Nevertheless, the twelve to fourteen mark differential between the other minority groups and Whites in verbal achievement narrows to four or five marks when all other factors are controlled by inclusion.

Quite substantially these results show that good teachers and good schools are important for educational achievement. Teachers average verbal right, class size, teachers' experience, school facilities and problems in the school have significant and important effects on the achievement measures. These variables are important components in the educational process.

Table II

Achievement Test

	Ver.	Non-V.	Reading	Math	Gen.Info.
B.	23.13	27.37	16.83	6.68	38.81
	(11.37)	(8.58)	(6.42)	(3.17)	(11.55)
W.	37.05	36.16	23.24	10.97	54.18
	(12.18)	(7.00)	(6.21)	(4.61)	(12.52)
P.R.	23.75	28.40	16.62	6.85	37.66
	(11.92)	(9.19)	(6.77)	(3.50)	(13.17)
M.A.	24.32	28.97	16.89	7.70	40.07
	(11.77)	(9.42)	(6.71)	(3.53)	(12.78)
Or.	34.67	36.48	21.45	10.99	50.78
	(13.24)	(7.88)	(6.62)	(4.75)	(12.60)
A.I.	24.56	31.51	17.39	7.83	42.41
	(12.17)	(8.25)	(6.44)	(3.67)	(13.04)
O.	29.19	32.15	18.56	8.56	44.71
	(13.46)	(8.68)	(7.23)	(4.20)	(14.39)

Average number of correct responses on the achie achievement tests across races--(standard deviations in parentheses)

B.= Black, W.= White, P.R.= Puerto Rican,
M.A.= Mexican American, Or.= Oriental,
A.I.= American Indian, O.= Other

APPENDIX I: DESCRIPTION OF THE VARIABLES

Abbreviation	Description	Mean	Standard Deviation
VR	Verbal Achievement	28.654	13.497
NVR	Non-verbal Achievement	31.512	9.107
RR	Reading Achievement	19.124	7.100
MR	Mathematical Achievement	8.597	4.347
GITR	General Informational Achievement	44.796	14.214
ACH	Achievement	0.099	3.664
MOT	Motivation	0.006	2.041
EXP	Expectations	0.020	1.666
EFF	Efficacy	0.007	3.271
$PAEXP^P$	Perceived Parents' Expectations	0.018	2.332
$TEXP^P$	Perceived Teachers' Expectations	-4.269	1.615
CONST	Constant	1.000	0.000
NEWENG	New England	0.028	0.165
MIDATL	Mid-Atlantic	0.215	0.411
LAKES	Great Lakes	0.149	0.356
PLAINS	Plains	0.045	0.206
SEAST	Southeast	0.215	0.411
SWEST	Southwest	0.097	0.295
BLACK	Black	0.265	0.441
WHITE	White	0.275	0.447
PRICAN	Puerto Rican	0.082	0.275
MEXAM	Mexican American	0.147	0.354
ORIENT	Oriental	0.081	0.273
AMIND	American Indian	0.081	0.273
PWPICLY	Proportion of white pupils in class last year	3.135	1.477
MLYBLCK	Mainly black school	0.366	0.482
MIX	Integrated school	0.101	0.302
SES	Socio-economic status	0.080	2.307
AVSES	Average socio-economic status	0.080	1.099
INFO	Information available	0.051	1.763
SMSA	Metropolitan Area	1.332	0.471
SEX	Sex	3.010	0.998
AGE	Age	4.067	0.916
NOBAS	Number of older brothers and sisters	2.877	2.159
TWOP	Two parents	0.642	0.479
FL	Foreign Language	3.219	1.071
RBS	Reading before school	2.395	1.199
PTAS	Parents talking about school	2.009	1.117
PTAAT	Parents attend PTA	1.702	1.024
NHWTV	Watching television	3.969	2.119
NHWTV2	(Watching TV)^2	20.244	16.901
TC	This city	0.755	0.430
NTCHSCL	Number of times changed school	2.586	1.524
LSTCHSCL	Last time changed school	6.004	1.651
TAVR	Teachers' average verbal right	24.382	2.295
NTPRPUP	Number of teachers per pupil	0.044	0.008
TANYTCH	Teachers' average number of years teaching	4.430	0.693
TANYTCH2	(Teachers' average number of years teaching)^2	20.108	6.196
PWTCHLY	Proportion of white teachers in class last year	3.647	1.626
TASEX	Teachers' sex	2.924	0.283
TPTC	Proportion of teachers from this city	0.426	0.255
PROBLEMS	Problems in the school	167.75	2.389
FACILITS	School facilities	12.346	1.799
AGES	Age of school	4.778	1.757
NTCHLV	Number of teachers who leave	2.152	1.396
TPADTN	Teachers' problems with administration	0.114	0.146
PRNMADEG	Principal has Master's degree	4.213	0.642
TEST	Testing experience	1.710	0.485
NTLKGC	Number of times talk to guidance counsellor last year	2.531	1.262

APPENDIX II: REDUCED FORM AND STRUCTURAL FORM ESTIMATES OF THE ACHIEVEMENT EQUATIONS

Dependent Variable	Verbal Achievement		Non-verbal Achievement		Reading Achievement		Math Ach
Explanatory Variable	Reduced Form	Structural Form	Reduced Form	Structural Form	Reduced Form	Structural Form	Reduced Form
ACH							
MOT							
EXP							
EFF		1.595 (12.792)		0.889 (9.944)		0.915 (13.450)	
PAEXP^P							
TEXP^P							
CONST	45.924 (6.172)	51.918 (7.288)	42.225 (8.074)	44.535 (8.750)	18.799 (4.576)	21.552 (5.965)	17.089 (6.724)
NEWENG	0.283 (0.481)		-1.515 (-3.671)	-1.333 (-3.568)	0.817 (2.521)	0.575 (2.023)	0.198 (0.988)
MIDATL	0.678 (1.904)		-0.798 (-3.188)	-0.927 (-5.073)	0.508 (2.583)		0.033 (0.273)
LAKES	0.240 (0.755)		-0.091 (-0.408)		0.245 (1.398)		0.156 (1.432)
PLAINS	1.990 (4.293)	0.750 (1.769)	0.391 (1.200)		1.760 (6.876)	0.951 (4.130)	0.857 (5.410)
SEAST	0.549 (1.439)		-1.192 (-4.450)	-1.489 (-7.162)	0.717 (3.407)		0.107 (0.820)
SWEST	-0.671 (-1.778)	-1.276 (-4.223)	0.157 (0.593)		0.418 (2.007)		-0.023 (-0.178)
BLACK	-1.508 (-3.790)	-2.642 (-6.882)	-1.302 (-4.658)	-2.207 (-10.137)	0.078 (0.357)	-0.360 (-2.182)	-0.986 (-7.259)
WHITE	4.115 (10.354)	2.408 (5.925)	2.222 (7.956)	1.085 (4.758)	2.485 (11.323)	1.827 (10.355)	1.354 (9.972)
PRICAN	-2.141 (-4.573)	-2.109 (-4.678)	-1.762 (-5.356)	-1.988 (-7.182)	-0.733 (-2.835)	-0.460 (-2.194)	-0.707 (-4.424)
MEXAM	-2.592 (-6.337)	-2.961 (-7.493)	-1.964 (-6.832)	-2.344 (-10.647)	0.830 (-3.679)	-0.792 (-4.607)	-0.643 (-4.600)
ORIENT	4.131 (8.941)	3.811 (8.632)	3.033 (9.340)	2.706 (9.859)	2.130 (8.353)	2.119 (10.028)	1.961 (12.425)
AMIND	-1.664 (-3.576)	-1.829 (-4.094)	0.538 (1.644)		-0.255 (-0.992)		-0.432 (-2.717)
PWPICLY	-0.008 (-0.077)		0.033 (0.437)		0.060 (1.028)		-0.028 (-0.774)
MLYBLCK	-2.448 (-7.926)	-2.211 (-8.370)	-0.277 (-1.274)		-0.647 (-3.798)	-0.677 (-4.459)	-0.698 (-6.621)
MIX	-1.609 (-4.628)	-1.770 (-5.597)	-0.602 (-2.464)	-0.643 (-3.018)	-0.493 (-2.567)	-0.723 (-4.105)	-0.462 (-3.894)
SES	0.972 (19.405)	0.717 (13.813)	0.394 (11.182)	0.246 (6.698)	0.368 (13.315)	0.225 (7.974)	0.230 (13.438)
AVSES	1.788 (15.267)	1.718 (15.584)	0.757 (9.198)	0.717 (9.362)	0.640 (9.894)	0.588 (10.388)	0.321 (8.025)
INFO	0.404 (6.640)	0.120 (1.898)	0.201 (4.694)		0.165 (4.925)		0.128 (6.146)
SMSA	0.194 (0.776)	-0.629 (-2.693)	0.016 (0.093)	-0.445 (-2.673)	0.417 (3.019)		0.259 (3.034)
SEX	-0.204 (-2.356)	-0.568 (-6.410)	-0.384 (-6.316)	-0.607 (-9.623)	0.535 (11.204)	0.336 (6.953)	-0.661 (-22.375)
AGE	-0.945 (-9.661)	-0.498 (-4.915)	-0.688 (-10.004)	-0.446 (-6.248)	-0.699 (-12.946)	-0.461 (-8.378)	-0.229 (-6.866)

Dependent Variable	Verbal Achievement		Non-verbal Achievement		Reading Achievement		Math Ach
Explanatory Variable	Reduced Form	Structural Form	Reduced Form	Structural Form	Reduced Form	Structural Form	Reduced Form
NOBAS	-0.355	-0.233	-0.220	-0.153	-0.209	-0.148	-0.037
	(-8.461)	(-5.530)	(-7.445)	(-5.150)	(-9.031)	(-6.505)	(-2.566)
TWOP	0.314		0.617	0.503	0.242		0.167
	(1.663)		(4.645)	(3.871)	(2.320)		(2.591)
FL	-0.618	-0.567	-0.367	-0.342	-0.199	-0.155	-0.080
	(-6.783)	(-6.444)	(-5.738)	(-5.487)	(-3.964)	(-3.223)	(-2.586)
RBS	0.450		0.056		0.233		-0.004
	(5.757)		(1.026)		(5.402)		(-0.143)
PTAS	0.581		0.316		0.176		0.128
	(6.996)		(5.414)		(3.837)		(4.497)
PTAAT	-0.446		-0.240		-0.332		-0.030
	(-4.991)		(-3.812)		(-6.717)		(-0.977)
NHWTV	0.446	-0.199	0.563	0.301	0.562	0.298	0.135
	(2.352)	(-4.935)	(4.226)	(2.248)	(5.367)	(2.888)	(2.078)
NHWTV2	-0.095		-0.076	-0.035	-0.082	-0.040	-0.033
	(-3.986)		(-4.509)	(-2.043)	(-6.188)	(-3.044)	(-4.012)
TC	-0.227		0.647	0.590	0.356	0.284	-0.113
	(-1.051)		(4.257)	(3.967)	(2.982)	(2.524)	(-1.531)
NTCHSCL	0.023		0.167	0.202	0.019		-0.057
	(0.354)		(3.631)	(4.489)	(0.535)		(-2.549)
LSTCHSCL	0.293		0.300	0.192	0.198	0.078	0.120
	(4.969)		(7.249)	(4.526)	(6.091)	(2.535)	(5.980)
TAVR	0.575	0.499	0.608	0.619	0.364	0.323	0.091
	(8.798)	(9.480)	(13.228)	(14.982)	(10.085)	(10.273)	(4.058)
NTPRPUP	23.076	36.405	19.935	23.697	21.033	25.231	2.534
	(1.882)	(3.346)	(2.314)	(2.894)	(3.108)	(4.225)	(0.605)
TANYTCH	-5.998	-4.404	-3.944	-2.804	-2.580	-1.627	-0.843
	(-5.322)	(-4.081)	(-4.979)	(-3.667)	(-4.147)	(-2.779)	(-2.190)
TANYTCH2	0.720	0.495	0.473	0.324	0.323	0.189	0.119
	(5.685)	(4.092)	(5.315)	(3.768)	(4.617)	(2.893)	2.740
PWTCHLY	0.038		0.253	0.209	0.164	0.097	0.006
	(0.415)		(3.886)	(4.023)	(3.213)	(2.315)	(0.174)
TASEX	-0.920	-0.580	-0.939	-0.799	-0.296		-0.296
	(-2.498)	(-1.771)	(-3.626)	(-3.217)	(-1.455)		(-2.349)
TPTC	-0.046		-0.023		-0.199		-0.296
	(-0.087)		(-0.062)		(-0.688)		(-1.658)
PROBLEMS	-0.082	-0.113	-0.090	-0.109	-0.037	-0.057	-0.036
	(-2.085)	(-2.975)	(-3.275)	(-4.083)	(-1.698)	(-2.826)	(-2.698)
FACILITS	-0.060		0.005		0.038	0.047	-0.051
	(-1.102)		(0.136)		(1.270)	(1.657)	(-2.758)
AGES	-0.097		-0.118	-0.123	0.058	0.078	-0.018
	(-1.607)		(-2.789)	(-3.138)	(1.750)	(2.561)	(-0.864)
NTCHLV	0.192	0.139	0.137	0.117	0.104	0.068	0.045
	(2.773)	(2.115)	(2.826)	(2.479)	(2.729)	(1.911)	(1.887)
TPADTN	3.719	3.188	1.527	1.207	1.501	1.153	0.504
	(5.920)	(5.373)	(3.458)	(2.836)	(4.328)	(3.505)	(2.349)
PRNMADEG	-0.728		-0.391		-0.577		-0.171
	(-5.054)		(-3.864)		(-7.253)		(-3.473)
TEST	1.109	0.984	0.499	0.463	0.314	0.250	0.445
	(5.341)	(5.077)	(3.417)	(3.333)	(2.743)	(2.389)	(6.281)
NTLKGC	0.712		0.485		0.384		0.215
	(9.960)		(9.656)		(9.722)		(8.810)
MLR^2	0.3606	0.4330	0.3063	0.3590	0.2958	0.3897	0.2809
$ALTR^2$	0.3606	0.3560	0.3063	0.3028	0.2958	0.2908	0.2809

Dependent Variable	Math Ach	General Informational Achievement	
Explanatory Variable	Structural Form	Reduced Form	Structural Form
ACH			
MOT			
EXP	0.314 (3.017)		
EFF	0.354 (5.755)		2.124 (16.344)
$PAEXP^P$			
$TEXP^P$			
CONST	16.454 (7.282)	68.931 (8.937)	74.780 (10.406)
NEWENG		-0.005 (-0.009)	
MIDATL		-0.126 (-0.341)	-0.935 (-3.133)
LAKES	0.185 (2.151)	0.214 (0.649)	
PLAINS	0.595 (4.038)	2.183 (4.544)	
SEAST		-0.066 (-0.167)	-1.217 (-3.989)
SWEST	-0.178 (-1.724)	-0.319 (-0.814)	-1.284 (-3.796)
BLACK	-1.414 (-10.957)	-1.512 (-3.667)	-2.610 (-8.227)
WHITE	0.909 (6.285)	4.756 (11.545)	3.116 (8.943)
PRICAN	-0.741 (-4.822)	-3.229 (-6.656)	-2.730 (-6.498)
MEXAM	-0.698 (-5.177)	-3.023 (-7.132)	-2.928 (-8.757)
ORIENT	1.894 (12.259)	4.393 (9.174)	4.113 (9.913)
AMIND	-0.496 (-3.245)	-0.458 (-0.949)	
PWPICLY		0.102 (0.925)	
MLYBLCK	-0.586 (-6.408)	-2.204 (-6.885)	-2.188 (-7.972)
MIX	-0.560 (-5.091)	-1.350 (-3.747)	-1.434 (-4.224)
SES	0.118 (5.151)	0.842 (16.205)	0.525 (9.503)
AVSES	0.261 (7.270)	1.594 (13.134)	1.491 (13.733)
INFO		0.560 (8.882)	0.227 (3.414)
SMSA		0.883 (3.407)	
SEX	-0.732 (-21.071)	-1.803 (-20.097)	-2.267 (-24.338)
AGE	-0.829 (-2.434)	-0.822 (-8.108)	-0.260 (-2.442)

Dependent Variable	Math Ach	General Informational Achievement	
Explanatory Variable	Structural Form	Reduced Form	Structural Form
NOBAS		-0.455 (-10.465)	-0.310 (-6.981)
TWOP	0.112 (1.809)	0.342 (1.745)	
FL		-0.267 (-2.832)	-0.168 (-1.797)
RBS		0.599 (7.404)	
PTAS		0.456 (5.295)	
PTAAT		-0.497 (-5.361)	
NHWTV		0.591 (3.004)	
NHWTV2		-0.100 (-4.055)	
TC		0.260 (1.162)	
NTCHSCL		0.006 (0.092)	
LSTCHSCL	0.071 (3.788)	0.391 (6.407)	0.122 (2.108)
TAVR	0.072 (3.960)	0.565 (8.337)	0.506 (8.199)
NTPRPUP	7.064 (1.914)	30.320 (2.386)	43.785 (3.614)
TANYTCH		-7.167 (-6.134)	-5.088 (-4.467)
TANYTCH2		0.867 (6.607)	0.566 (4.396)
PWTCHLY		0.292 (3.039)	
TASEX	-0.205 (-1.834)	-0.663 (-1.736)	
TPTC	-0.257 (-1.928)	-1.315 (-2.426)	-0.934 (-1.886)
PROBLEMS	-0.045 (-3.571)	-0.110 (-2.708)	-0.145 (-3.675)
FACILITS		-0.115 (-2.044)	
AGES		-0.050 (-0.797)	
NTCHLV		0.136 (1.892)	
TPADTN	0.442 (2.175)	2.742 (4.211)	2.326 (3.684)
PRNMADEG		-0.604 (-4.045)	
TEST	0.447 (6.596)	0.901 (4.187)	0.839 (3.953)
NTLKGC		0.812 (10.950)	
MLR^2	0.3362	0.3806	0.4745
$ALTR^2$	0.2750	0.3806	0.3772

Bibliography

[1] Aiken, L.R., "Ability and Creativity in Mathematics," Review of Educational Research, 43, Fall 1973, pp. 405-432.

[2] Boardman, A.E., Review of On Equality of Educational Opportunity, Mosteller and Moynihan (eds.), Journal of the American Statistical Association, 68 June 1973, pp. 489-491.

[3] Boardman, A.E., Davis, O.A. and Sanday, P. R., "A Simultaneous Equations Model of the Educational Process," School of Urban and Public Affairs, Carnegie-Mellon University (submitted for publication).

[4] Boardman, A.E., Davis, O.A. and Sanday, P. R., "Education From An Anthropological Perspective: An Empirical Investigation of Structural Differences Among Blacks and Whites," School of Urban and Public Affairs, Carnegie-Mellon University, presented at the Conference on the Contributions of Anthropology to Public Policy Formulation, Philadelphia, October 1973.

[5] Buros, O.K., (ed.), Fourth and Fifth Measurements Yearbook, Gryphon Press, Highland Park, N.J., 1953 and 1959.

[6] Coleman, J.S., Campbell, E.Q., Hobson, C.J., McPartland, J., Mood, A.M., Weinfield, F.D., and R.L. York, Equality of Educational Opportunity, Washington, D.C., U.S. Government Printing Office, 1969.

[7] Dwyer, C.A., "Sex Differences in Reading: An Evaluation and a Critique of Current Theories," Review of Educational Research, 43, Fall 1973, pp. 455-467.

[8] Gordon, C., "Looking Ahead: Self-conceptions, Race and Family as Determinants of Adolescent Orientation to Achievement," Rose Monograph Series, American Sociological Association, 1973.

[9] Hanushek, E.A., Education and Race, Lexington: D.C. Heath, 1972.

[10] Hechinger, F.M., "Home is a Crucial Factor," New York Times, Section E., p.9, May 27, 1973.

[11] Jencks, C., et al., Inequality, Basic Books, 1972.

[12] Levin, H.M., "A New Model of School Effectiveness," in Do Teachers Make a Difference?, U.S. Government Printing Office, 1970, pp.25-78.

[13] Mayeske, G.W., et al., "A Study of our Nation's Schools," working paper, U.S. Department of Health, Education and Welfare, Office of Education (not dated).

[14] Mosteller, F. and Moynihan, D.P. (eds.), On Equality of Educational Opportunity (OEOEO), Random House, 1972.

[15] Purves, A. C., Literature Education in Ten Countries, Wiley: New York, 1973.

[16] Stafford R.E., "Hereditary and Environmental Components of Quantitative Reasoning," Review of Educational Research, 42, Spring 1972, pp. 183-201.

[17] Toward Equal Educational Opportunity. The report of the Select Committee on equal educational opportunity, United States Senate, U.S. Government Printing Office, Washington, D.C., 1972.

FOOTNOTES

* The authors thank Professors Timothy McGuire, Joseph Kadane and Edwin Fenton of Carnegie-Mellon University, and Professor Henry Levin of Stanford University for helpful comments on earlier drafts of this and related work. David Rattner, now of Princeton University, performed invaluable programming assistance during the past summer. Finally, we are indebted to the Ford Foundation, the U. S. Office of Education, and the National Science Foundation for financial assistance. The authors accept full responsibility for the opinions expressed in this paper and for any remaining errors.

1. We estimated the model by two stage least squares. Our sample consisted of over 16,000 twelfth grade students from all regions of the country and with different ethnic backgrounds.

2. Several such hypotheses can be found in the first reports of the on-going study by the International Association for the Evaluation of Educational Achievement, IEA. See Hechinger[10].

3. Ambiguously, the Coleman Report refers to some tests as measures of ability, and some as measures of achievement. We prefer to regard them all as achievement measures.

4. See Boardman [2], for a thorough review of OEOEO.

5. See Dwyer [7], for example.

6. For a thorough view of Levin's work, see Boardman, et al. [3]

7. Appendix I contains brief operational definitions of these variables. More detailed descriptions are available upon request.

8. The ETS took the verbal test from the School and College Ability Tests, SCAT. The non-verbal test came from the Interamerican Tests of General Ability. The reading and mathematical tests were each one-half of a test from the Sequential Tests for Educational Progress, STEP. The ETS based the general informational test questions on items used in their earlier research studies. These comments apply only to the ninth and twelfth grade tests. More information on some of these tests appear in the Mental Measurements Yearbooks [5].

9. See the EEOR, p. 20.

10. The ETS calculated a scale score for the verbal, non-verbal and reading tests, but not for the other tests. We could have corrected for guessing, but the instructions specifically stated that the students' score depended on the number of correct answers.

11. The above results suggested that there was only a single latent factor. We performed a factor analysis with squared multiple correlations as communality estimates and found strong evidence of only one factor. A varimax rotation on the factor matrix for the cases N=2 and N=3 suggested that even if the second factor was not in error, it was not a non-verbal factor (on the varimax rotated factor matrix for N=2 mathematical right had the highest loading of 0.73 followed, in order of magnitude, by general informational right with a loading of 0.52).

12. All variables in the structural equations have a level of confidence in excess of 0.95 for a one tailed test. The table presents t-statistics in parentheses. MLR^2 means the R^2 is calculated using observed values of endogenous variables; $ALTR^2$ uses predicted values.

13. Single equation estimation techniques are likely to show that motivation has a sifnificant direct effect. For example, see Hechinger's article [10], on the recent IEA findings.

14. The research classifies students who do not consider themselves members of the given racial groups as "Other"; we excluded this category from the regressions.

15. To answer this question more fully, one should consider the ethnic groups individually. See Boardman et al. [4]

16. See Toward Equal Educational Opportunity [17] p. 235.

17. See, for example, Jencks in OEOEO [4], pp. 82-83.

18. Average socio-economic status acts like the IEA's sailing handicap. See, for example, Purves [15] pp. 121-125.

19. See Dwyer [7] for a full discussion of the alternative theories.

20. See Jencks [11], for example.