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THE DETERMINANTS OF SCHOOL ACHIEVEMENT: A Review of the Research for Developing Countries

Prepared for the Educational Research Review and Advisory Group



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THE DETERMINANTS OF SCHOOL ACHIEVEMENT: A REVIEW OF THE RESEARCH FOR DEVELOPING COUNTRIES

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The Determinants of School Achievement: A Review of the Research for Developing Countries

This paper reviews results of twenty-six studies on the determinants of student cognitive achievement in developing countries. It describes the studies, reviews the results for each of the major determinants of cognitive student achievement - schooling characteristics, teachers' attributes, and student traits - and concludes with the implications for policy and research.

The manuscript was commissioned by the Research Review and Advisory Group as part of a larger examination of educational research as it relates to educational problems in developing countries. It is intended that the information gathered will be helpful to institutions in the developing countries concerned with education policy, programmes, research and training, and to international funding organizations.

FOREWORD

(by Robert G. Myers)

For many years a tradition of classroom research rooted in psychology and pedagogy dominated the field of educational research. With the availability of computers and with increasing interest and involvement in educational research by sociologists and economists, a "new" approach to studying influences on educational performance emerged in the 1960s and 1970s. This approach combines several features:

- using national surveys to gather data about a wide range of possible influences on learning, including extra-school influences;
- using multivariate or "systems" analysis to sort out the relative importance of a number of the possible "determinants"; and
- 3) applying the concept, taken from economics, of the "production function".

The literature abounds with previous reviews and critiques of studies adopting a systems approach to identifying determinants of school achievement. However, these reviews have been, with one dated exception, ¹ of research done in the United States, the United Kingdom, or elsewhere in the developed world.² Meanwhile, determinants studies have proliferated in the developing world. It remained to pull together and interpret results, as has been done in the following pages.

The authors of this paper have assumed readers are familiar with standard critiques of studies using multiple regression techniques and based on an education production function model (EPF).³ They have, moreover, taken a relatively cautious view in their own interpretation of the research results reviewed, drawing only from the statistically significant findings suggestions for promising lines of experimentation. Their treatment of EPF studies may not be nearly cautious enough for some, however, who not only point to problems of definition, measurement, and method but who questions the very assumptions and concepts central to such research. For example:

"A major deficiency in research on education-production functions... arises from the fact that (they) are based on the attempt to link statistically a list of inputs with a particular output, without the assistance of any theory... The (persisting) lack of theoretical development...is likely to derive from the underlying complexity of the phenomena that are being explored or other obstacles that prevent the type of simplification and reductionism that are necessary for the systematic construction of a conceptual framework."⁴

Even the critics, however, admit that results of the EPF studies have been consistent in at least two important respects, indicating that (1) student backgrounds markedly affect their achievement, and (2) the potential effects of providing additional or improved school resources is greater for students from lower social status than for higher. Providing textbooks, for instance, can improve performance for students from lower SES backgrounds but does little for higher SES peers. These two observations hold up in the work from developing countries, with one difference -- that the combined "school effects" are generally more pronounced and sometimes outweigh the non-school effects on achievement. Indeed, the leeway for affecting performance by improving the condition of schools and what goes on in them seems to be greater than in the more homogeneous developed world.

In a related activity,⁵ the Research Review and Advisory Group sponsored, in May 1978, a meeting in Singapore at which national studies were discussed. There, a point was made of the importance of treating results from EPF research with care, and of complementing such research with observational studies. However, a forceful case was made also for the value of large-scale empirical studies of the type reviewed here as devices for providing (1) descriptive data pointing to existing inequities in participation and performance in national systems of education and (2) a new vocabulary for policy-makers - one which includes social dimensions.

The authors have performed a valuable service in bringing together these results and in pointing to particular variables that have emerged, in their opinion, as promising for action and for further examination. Their interpretations are their own, of course. To the extent their views spark discussions, provoke experimentation with new programs and stimulate research using complementary methods,⁷ this publication will have served its purpose.

References

¹ John Simmons and Leigh Alexander, "The Determinants of School Achievement: A Review of the Research", <u>Economic Development</u> <u>and Cultural Change</u>, Vol: XXV1, No. 2 (January, 1978), pp. 341-357.

² See, for example: Harvey Averch, et al., <u>How Effective is Schooling</u>? Englewood Cliffs, N.J.: Educational Technology Publications, 1974; Eric Hanashek, "A Reader's Guide to Education Production Functions", Working Paper No. 798, Institution for Social and Policy Studies, Yale University, New Haven, Conn., 1977.

³ A production function analysis treats education, usually schooling, as a process in which labor and capital "inputs" (such as teachers, books, buildings) are combined to produce "outputs" (for instance, an increase in knowledge, or, more simply, graduates) in the most efficient manner. Both "inputs" and "outputs" are difficult to specify and measure. Strong intercorrelations among "determinants" makes it difficult to sort out their unique effects: similarly schools produce simultaneously several outcomes but research usually deals only with cognitive achievement. The models used often assume (incorrectly?) linear relationships. Results are sensitive to the level of aggregation used. Often it is not additions to performance but level of performance that is used.

⁴ Henry M. Levin, "Educational Production Theory and Teacher Inputs", Revision of a paper prepared for a July 6-8 conference held at the Educational Finance and Productivity Center of the University of Chicago. Stanford University, August, 1978, p. 4 (mimeograph).

⁵ Susanne Mowat, Rapporteur. "The Genesis, Conduct and Utilisation Educational Research: A Report on a Workshop Reviewing Four National Education Assessment Studies -- Indonesia, Malaysia, the Philippines, and Thailand", Ottawa: International Development Research Centre. The Research Review and Advisory Group, 1978.

⁶ For an excellent discussion of concepts and methods associated with production function and classroom traditions of research, see: Rebecca Barr and Robert Dreeben, "Instruction in Classrooms", in Lee S. Shulman (ed.), <u>Review of Research in Education 5</u>, Itasca, Illinois: F.B. Peacock Publishers, Inc., forthcoming.

CONTENTS

PAGE

Foreword	
Introduction and Summary	1
The Studies	6
School Characteristics	13
Teachers' Characteristics	16
Student Traits	19
Implications for Policy and Research	21
About the Authors	
Annex I Determinants of Achievement by Region	

Determinants of Achievement by Region I

Regression Equations for Selected Studies (on request) II

Text Tables

- Description of Multivariate Studies by Region 1.
- 2. School Attributes Ranked by Frequency of Study
- 3. Teacher Attributes Ranked by Frequency of Study
- 4. Student Attributes Ranked by Frequency of Study
- 5. Summary of the Determinants
- 6. Comparison of the 1974 and 1978 Reviews

Introduction and Summary

Research exploring why some children learn more in school than others has revealed important issues for planners and educators in developing countries.¹ The investigations have used the methods of anthropology, psychology, sociology, economics, linguistics, and statistics. Some studies have examined the effects of different curricula on student learning, others have concentrated on studies of student and teacher interaction, still others have described as fully as possible what happens in the classroom and during homework. A separate group of studies has tried to understand the learning process as a complex system of factors affecting student achievement which includes the influence of family, the characteristics of the student, other non-school experiences and the role of the school. These system studies draw on all the disciplines and have been of particular interest to planners and educators because they attempt to estimate the relative effect of the inputs which, in theory, have an impact on student achievement.

Our purpose is to highlight selected results from system studies carried out by researchers in more than 20 developing countries. We will draw policy implications from both the research methods and the findings, and will suggest future research. Our review is limited to twenty-six studies using multivariate analysis, the most rigorous of the statistical tools, and includes twelve studies reported in the six years since the last review was completed. We draw also upon recent reviews which have examined single dimensions of the system like the effect of textbooks or class size on student achievement.

<u>Findings</u>. We divided the possible determinants of student achievement into three categories: school resources and processes, teacher attributes, and student traits. It is important to note that these are determinants <u>in</u> <u>theory</u>, but not necessarily in practice. We would expect them to have a significant impact on student achievement, as measured by both statistical estimations and classroom learning.

We appreciate the comments of Claudio de Moura Castro, Dagmar Raczynk, Mello Souza, Gilda Romero, Stephen Heyneman, Dean Jameison, Henry Levin, Robert Myers and our other Research Review and ^{Advisory} Group colleagues on earlier drafts.

A) Twenty-six studies provide evidence on thirteen dimensions within the category of <u>school resources and processes</u>. We shall discuss these policy-related variables for which there are the most observations, including class size, the availability of textbooks, and expenditure per student.

- 1. The optimal <u>number of students per class</u> is an important policy issue because of its cost implications. In 9 of 14 studies relating the effects of class size to student achievement, larger class size was associated with higher performance or did not affect it. Relatedly, five of the eight studies examining the relationships between cost per student and student achievement found that higher expenditure per student is not associated with higher student achievement. The implication is that raising the class size 20 to 30 percent <u>might</u> not decrease student achievement. With this, and other findings, however, it is important to experiment with the suggested changes <u>before</u> policies are endorsed and implemented on a national scale. Increasing the class size for instance might cause negative reactions by some teachers and, as a result, lower scores. Or, implementation of new teaching methods may require a smaller class size.
- 2. Of 10 studies looking at the availability of <u>textbooks</u> and student achievement, 7 demonstrated a positive relationship. While this is a strong finding, one could ask why it is not stronger. Where results are negative the textbooks may not be well designed to teach what the students are being tested or teachers may not efficiently use the books that they have. It is also possible that oral or blackboard presentation of the information being tested is sufficient, and textbooks are not needed.
- 3. Students who have schoolwork to be done outside of school, i.e. "homework", tend to do better on the achievement tests in 6 of the 8 studies. None of the other school determinants of achievement have as high a proportion of significant findings. This is an interesting policy variable because it is virtually costless in money terms and seems to provide a high return.

B) The studies reviewed include information about 16 dimensions of <u>teachers' characteristics</u>. The dimensions for which there are the most observations are teacher certification, experience and training.

- In 19 out of 32 studies, <u>teachers without certificates</u> in educational training had students who tested as well as those who had certificates. While additional information must be obtained to draw more meaningful conclusions from these studies, in the meantime it is possible to suggest that teacher certification should be reviewed with caution as a way to increase student achievement.
- 2. Years of teacher experience is a significant determinant of achievement in only 7 of 19 studies. Teacher experience might be related to cultural traditions, or administrative procedures. More experience might correspond with less exposure to new methods and approaches in education, or older teachers might be assigned to classes with higher performance.
- 3. More years of <u>training</u> is not related to higher student achievement in 5 out of 6 studies. If experimental work were to confirm this finding, it would have substantial implications for training requirements.

C) <u>Student traits</u> are significant in the expected directions in 47 cases, while no impact or an opposite result are found in only 17 cases. Results are especially consistent across students for variables such as socioeconomic status of parents (SES), repetition, malnutrition, health, and pre-primary education.

 <u>SES</u> is the variable most frequently studied in this set. Out of a total of 13 observations, SES is a significant predictor in 10. In several studies family background is the single most important determinant of school outcomes. It is usually a composite measure of parents occupation, incomes and education. Upperincome children may tend to learn the language skills and other

- 3 -

behaviors rewarded by schools. They also have access to books, literate parents, toys and other conditions at home. Parent training of the poor could offset some of these advantages. Thus the design of new educational policies should pay attention to the possible effects of family background.

2. <u>Malnutrition, body weight and health</u> are significant predictors of scores in 8 of 11 cases, a surprisingly consistent finding across studies. The finding provides strong support for experiments to raise health levels as a form of educational investment. Nutrition or health are highly correlated with SES; thus it is uncertain in those studies where SES is not well measured whether these variables are important on their own, or only an indicator of the economic status of families.

The data on health (mentioned above) indirectly suggests the role of parents in contributing to child health and student achievement, even when their socioeconomic status is controlled. Experiments on parent training and other pre-school factors could yield important policy results.

- 3. <u>Repetition</u> studies have shown that the more repeating a student did, the lower the score, in 7 observations out of 8.
- Three of the 4 observations about <u>kindergarten attendance</u> indicate that it has a significant impact on student achievement measured 6 or 12 years later.

Data from the 33 studies are summarized in the table below (Table 1) From a total of 101 measures of school characteristics, 45 were statistically significant determinants of achievement.

Table 1: SUMMARY OF THE POSSIBLE DETERMINANTS (number of observations)

·	Significant	Other	Total	Percentage Significant
School Characteristics	47	51	98	48
Teacher Attributes	29	51	80	36
Student Traits	47	17	64	75
TOTAL	123	119	242	51

1. Multiple regression coefficients are statistically significant at the .05 level or better.

Implications for Policy and Research: What policy and research implications can be drawn from these highlights? These studies have selected a small number of main determinants for pilot projects and experimental research from a large pool which were assumed to be significant. For policy planning, then, those variables that are labelled significant "determinants" should be considered as possible, but not certain, inputs to cognitive achievement as measured by school tests. This uncertainty is due to limitations of the cross-sectional regression analysis and of the data. The tests do not measure all aspects of cognitive achievement, nor do they measure any dimensions of students' affective development like co-operation, responsibility or leadership. Nevertheless, results should encourage policy planners to undertake pilot projects, for example, increasing class size, initiating homework, and improving early child development. Because these variables are themselves often linked casually, experiments should seek those combinations that will be most effective in improving overall performance of the system.

In short, we do not feel that additional national multivariate analyses should be given a high priority. However, studies which probe deeper into specific questions (for example exploring the situation in rural or marginal areas), or periodic repetitions of the surveys to document changes in performance and distribution over time may be in order. And, in countries where experimentation is not feasible, then multivariate studies may be the only way to raise awareness about the possible determinants of achievement. If and when such additional surveys are done, attention should be given to non-cognitive as well as cognitive outcomes. To associate the desired outcomes of an educational system only with academic achievement is, of course, a narrow view. Surveys should be accompanied also by observational studies.

Reanalyses of the present data could be done within social or geographic groupings, with particular attention to determinants of achievement for low SES students.

In conclusion, the multivariate studies have provided important information for policy and research in developing countries by screening approximately ten variables for more than 500 for further examination. The next step is to undertake experimental studies assessing their impact as policy variables on achievement and other educational outcomes.

The Studies

This paper concentrates on presenting the results of the multivariate or "production function" studies of the effects of school, teacher, and student characteristics. We make comparisons across the African, Asian, and Latin American regions and explore the conclusions. Our analysis is limited to multivariate studies because they provide better insight than simple correlation studies for both policy planning and research design. Since a critique of the production function theory and estimation procedures can be found elsewhere, we have not replicated it here.² We were able to locate only 2 experimental studies.³

- 2 John Simmons and Leigh Alexander, "The Determinants of School Achievement: A Review of the Research", Economic Development and Cultural Change 26, No. 2 (January 1978) pp. 341-357. For reviews of specific determinants see Wadi Haddad, "Educational Effects of Class Size", (Washington, D.C.: World Bank Working Paper, No. 280, 1978); Institute of International Education, Stockholm University, "Teacher Training and Student Achievement in Less Developed Countries", mimeo (Washington, D.C.: World Bank, Education Department, 1978); Joseph P. Farrell, Manual A. Sepulveda-Stuardo and Stephen Heyneman, "Textbooks and Achievement: What We Know", mimeo (Toronto: Ontario Institute of Studies in Education, June 1978); and Beatrice Avalos and Wadi Haddad, "Teacher Effectiveness", mimeo (Ottawa: International Development Research Centre, 1978).
- ³ One is the Radio Mathematics Project in Nicaragua; the second is the Textbook Project in the Philippines. Both are randomly assigning schools to various treatment conditions involving high, low, or zero levels of school resources likely to be important in influencing achievement - radio

(con't.../)

Twenty-six studies are represented in this review: 5 for Africa, 6 for Asia and 15 for Latin America. This compares with 14 studies available for review in 1974.⁴ We include all multivariate studies covered in recent topical reviews. The studies are described by region in table 2 on the following pages.5

Some studies present only one production function for the whole sample, while other studies present results for each subsample. For example, when the Thai study presented equations for 3 economic groups, each equation is presented as a separate observation. Finally each study examined several characteristics of each major determinant, like teacher motivation, and training of the teacher determinant. We have 102 observations on the school characteristics of achievement, 80 on teacher attributes, and 64 on student traits.⁶

We categorized in Annex 1 the determinants into those which were "statistically significant with the expected sign" and were "not statistically significant, or with the opposite sign".⁷ Statistical significance may or may not signify policy significance; more research is needed to determine it. But it does help us to begin to sift through the more than 500 variables that have been studied for their possible importance in promoting student achievement. We grouped those determinants which were not significant with those which had a reversed sign into 1 rather than 2 categories to clarify the possible policy implications. The classificational system is

- (con't) 2. and textbooks in Nicaragua, and radio, textbooks, and in-service teacher training in the Philippines. Both use multivariate methods, or production functions, to relate achievement to the experimentally assigned and other variables.
- 4 See Simmons and Alexander, 1978. See also L.J. Lair, "Educational Production Functions" in D. Windham (ed). <u>Economic Perspectives in Education</u>, forthcoming.
- 5 The reader should be aware after reading Table 1 that the studies differ in: size and the degree to which samples are representative; the definition and measurement of the dependent variable; and the number of and definitions of variables included as determinants.
- 6 Annex 2 which is available on request provides copies of the more important equations from many of the studies that we have used. We hope that readers who are aware of studies we have omitted will send us copies including the equations.
- 7 A given variable may have several definitions, affecting the results. Also, the order in which variables are included in regressions may affect their significance.

- 7 -

Author(s) and		Sample		2			
Publication Date Country	Country	Primary or lower Secondary grade	Upper Secondary grade	R ² Range	Measure of Student Academic Achievement		
Youdi, 1971	Congo		1450 students in grade 11 and 12 randomly selected from 25 secondary schools		Individual scores on IEA multiple choice tests in French and mathematics.		
Simmons, 1972	Tunisia	44 students from a village and 80 students from an urban suburb, grades 4-8		 	Individual scores on multiple choice tests in Arabic, French, and arithmetic.		
Thias-Carnoy, 1973	Kenya	3405 rural grade 7 students in a random sample of 89 schools	·	 	Average student scores on Kenya • Preliminary Examination for each school.		
			Grade 11 students in 115 rural and urban schools		Average student scores on Cambridge School Certificate Examination for each school.		
Carnoy-Thias, 1974	Tunisia	6195 students in grades selected from rural and schools	7-11 randomly urban secondary		Individual student grade point averages on school examinations.		
Heyneman, et.al. 1977 (data 1972)(Table 3)	Uganda	2293 grade 7 students in 67 schools		.35	Individual scores on Uganda school selection exams in English, mathematics, and general knowledge		

TABLE 2A : DESCRIPTION OF SYSTEMS STUDIES EXPLAINING STUDENT COGNITIVE ACHIEVEMENT IN AFRICA

¹ The statistical procedures for these studies were all ordinary least squares procedures

Author(s) and Data		Sample	e	2	
Collection Date Country	Primary or lower Secondary grade	Upper Secondary grade	R ² Range	Measure of Student Academic Achievement	
M. Costa, 1977	Brazil	1658 eighth grade students Sao Paulo		.27 to .34	Individual scores on reading and math test.
L. Wolff, 1970		20 120 first grades in Rio Grande do Soul		.04 to .16	Student grades in language as recorded by the teacher
J. Mayo, R. Hornik and E. McAnany, 1969	El Sal vad or	1600 students of grades 7, 8, 9		.49 to .87	Individual scores on GTA developed general ability and reading test
S. Schmelkes, 1972		l6l students in 24 schools grades 1-4			Arithmetic, geometry and language test scores.
C. Munoz and J.T. Guzman, 1971	Mexico	519 students of grades 3,4,5 in Mexico City (private schools) for low SES sectors		.23	Individual scores on arithmetic and Spanish texts developed by Inst. Nac. de Pedagogia
S. Klees, 1974	Mexico		1236 students in 58 telesecundarias		Math and language.
F. Swett, 1976	Ecuador	3146 students in grades 1, 4, 6		.16 to .92	Individual scores in verbal and math test
E. Echart, J. Meier, R. Manuel li and M. Binimelis, 1976	Argentina	2130 students in grades 1,4,6	230 in Bachiller and technical education		Individual scores in verbal and math test

TABLE 2B: DESCRIPTION OF SYSTEMS STUDIES EXPLAINING STUDENT COGNITIVE ACHIEVEMENT IN LATIN AMERICA

-9 -

Author(s) and Data		Sam	ple	2			
Collection Date Country	Primary or lower Secondary grade	Upper Secondary grade	R ² Range	Measure of Student Academic Achievement			
D. Rivarola and G. Corvalan, 1976	Paraguay	3688 students of gra last course in secor	ndes 4 and 6 and ndary	.12 to .36	Individual scores on arithmetic and Spanish ELIEL adaption of IEA test		
Comber & Keeves, 1973	Chile		Final year in high school; 73 schools and 2052 students (IEA-IV);81 & 1470 (I); 103 & 1311 (II)		,		
A.C. Purves, 1973	Chile		88 <u>1</u> 9		IEA test on sciences		
J.B. Carroll, 1973	Chile		1549 students in 60 schools (IEA-IV)		IEA test on French		
Lewis & Massod, 1975	Chile		2314 students in 80 schools (IEA-IV)		IEA test on English		

DESCRIPTION OF SYSTEMS STUDIES EXPLAINING STUDENT COGNITIVE ACHIEVEMENT IN LATIN AMERICA

Author(s) and Data		Samp	le	2				
Collection Date Count		Primary or lower Secondary grade	Upper Secondary grade	R ² Range	Measure of Student Academic Achievement			
E. Schiefelbein and J. Farrell, 1973	Chile	3530 students in 8th grade in 1970		.30	Individual scores on national grade 8 test in Spanish and arithmetic			
E. Schiefelbein and C. Clavel, 1972 and 1974	Chile		162 high school students in their last year in 1972	.29 to .99	H H H H			

DESCRIPTION OF SYSTEMS STUDIES EXPLAINING STUDENT COGNITIVE ACHIEVEMENT IN LATIN AMERICA

Author(s) and		Samp]	e	Statistical 2			
Publication Date	Country	Primary or lower Secondary grade	Upper Secondary grade	Procedure R ² Ran ge	Measure of Student Academic Achievement		
Beebout, 1972	Malaysia		7674 students in grades 10-11 in a random sample of 89 secondary schools	OLS multiple regression using both a quadratic and linear func- tional form	An index of individual student performance relative to that of his peers; per- formance defined as the difference between secondary entrance and final examina- tion scores.		
Comber-Keeves, 1973 Thorndike, 1973 (IEA Study)	India	2662 students age 10 in 176 schools and 2845 students age 14 in 155 schools	3040 students in terminal year of full-time secondary program in a sample of 127 secondary schools.	Stepwise OLS multiple regression	Individual scores on inter- nationally developed multiple choice tests in science and native language reading comprehension.		
	Iran	1623 students age 10 in 53 schools and 1020 students age 14 in 33 schools	1051 students in terminal year of full-time secondary program in 40 schools	11 II	- 12 -		
	Thailand	1822 students age 10 in 27 schools and 1924 students age 14 in 29 schools	723 students in terminal year of full-time secondary program in 15 schools	и и	и и		
Haron, 1977 (data 1972)	Malaysia	6056 students of age 12 from a stratified random sample		OLS multiple regression	Individual scores on the "Standard Five Assessment Examination" commonly used in Malaysia.		
Fuller & NEC, 1977 (data 1973-74)	Thailand	23555 students from grade 3 in 987 schools		Stepwise OLS .09- multiple .26 regression	Individual scores on stan- dardized achievement tests of Thai language and arithmetic administered at entrance and completion of grade 3.		

TABLE 2C: DESCRIPTION OF SYSTEMS STUDIES EXPLAINING STUDENT COGNITIVE ACHIEVEMENT IN ASIA

also consistent with the earlier review, and makes comparison between them easier. It should be noted, however, that some studies of a determinant, like teacher certification, which were expected to have a positive impact on achievement in fact had a negative impact.⁸

School Characteristics

We have reviewed studies providing evidence on 16 dimensions of school resources and processes. These dimensions range from expenditure per student and class size to the availability of textbooks, homework assignments, curriculum and peer group effects. But in eight cases, there are results for only one of the regions. This fact suggests the need to explore these variables in the remaining regions. Table 3 below summarizes the findings for each school variable on student achievement by region.⁹ Of the 98 observations of schooling and achievement, 47 had statistically significant effects while 51 had either no impact or an impact in the opposite direction than was expected.

The differences among the three regions and different aspects does not appear significant.¹⁰ For each, half of the variables have a significant impact than have either no impact or a significant opposite impact. It might be noted that there are more data on expenditures per student and class size from Latin American than there are from Africa or Asia, while the studies of textbook availability are predominantly from Asia. We shall discuss the findings on the policy variables for which there are the most observations, including average class size, the availability of textbooks, homework and expenditure per student.

<u>Class Size.</u> The optimal number of students per class is an important issue because of its cost implications. In 9 out of 14 studies testing the effects of class size on student achievement, larger class size was found to either improve or not affect performance. Five of the 8 studies that examine the relationships between cost per student and student achievement found that higher expenditure per student

- 9 Each study may include several measurements of school variables.
- 10 The comparison is limited by methodological problems mentioned above.

- 13 -

⁸ Readers interested in these and other distinctions can request the equation in Annex II.

is not associated with higher student achievement.¹¹ Some countries that were studied have an average class size from 25 to 50 students. The implication is that raising the national average class size 20 to 30 percent might not decrease student achievement.¹² The magnitude of this estate is based on the regression coefficient and standard deviation of class size. However, increasing the class size might cause negative reactions by some teachers and, as a result, lower scores, or, implementation of new teaching methods might require a smaller class size. Thus, it is important to experiment with the critical changes <u>before</u> policies are endorsed and implemented on a national scale.¹³

<u>Textbooks</u>. Ten studies looked at the relationship between the availability of textbooks and student achievement, of which seven demonstrated a positive relationship.¹⁴ Based on the central role that textbooks could play in most classrooms, it may be surprising to some observers that the number is not higher. It is possible that the textbooks are not welldesigned to teach what the students are being tested or that the teachers do not efficiently use the books that they have. It is also possible, for certain educational goals, that oral or blackboard presentation of the information being tested is sufficient, and the textbooks are not needed. Finally, it may be that textbooks are only useful for rote learning and are not sufficient (without changes in the role of the teacher) for achieving higher levels of skills - making inferences or judgements, for example.

There are other problems with the analysis of this variable. If textbooks are bought by the student, they may be a proxy of socioeconomic status (SES). If students do not have textbooks because the teacher does not ask the students to buy them, the variable becomes a proxy of teaching methods. Only when students lack the textbooks required by their teachers

- 12 Increasing the average does not mean all classes would be larger and could be consistent with a policy to reduce the size of the largest classes.
- 13 For a full discussion of class size and related issues see Wadi Haddad, <u>op.cit</u>.
- 14 The three cases correspond to the Thailand study. There are more studies examining the issues of textbook impact but using simple correlations. See J. Farrell, M. Sepulveda and S. Heyneman, <u>op.cit</u>.

¹¹ Higher expenditures may simply reflect inefficiencies in the deployment of resources or indivisibilities of some factors, neither of which affects learning. The Latin American schools seem to display great variation in inefficiency. See: Claudio Castro, <u>et.al.</u>, "La Educacion en America Latina: Un Estudio Comparativo de Costos y Eficiencia", Rio de Janeiro, Programa de Estudios Conjuntos sobre Integracion Economica Latino Americana, 1978; p. 90

	AFRICA Signif. Other ²		LATIN AMERICA Signif. Other		ASIA Signif. Other		TOTAL Signif. Other		A11
Average class size	0]	2	5	3	3	5	9	14
School facilities ²	1	2	2	2	2	3	5	7	12
Textbook availability	١	0	2	0	4	3	7	3	10
School size	1	ı	0	0	4	4	5	5	10
Expenditure per student	0	1	3	3	0	1	3	5	8
Homework assignment	1	0	2	2	3	0	6	2	8
Total years of science	0	0	0	0	4	4	4	4	8
Boarding at secondary	3	1	0	0	0	1	3	2	5
Double shifts	0	0	0	1	1	0	1	ı	2
Student-made science observations & experiments	0	0	0	0	1	2	1	2	3
Distance to home	0	0	0	0	2	1	2	1	3
Coed student body	0	0	0	3	0	0	0	3	3
Percentage of teachers who teach science	0	0	0	0	0	3	0	3	3
Time devoted to science study & homework	0	0	0	0	1	2	1	2	3
Library utilization	0	0	0	2	0	0	0	2	2
School year length	0	0	2	0	0	0	2	0	2
Classroom peer group	1	0	0	0	0	0	1	0	ı
Extracurricular activities	0	0	1	0	0	0	1	0	1
TOTAL	8	6	14	18	25	27	47	51	98

TABLE 3: SCHOOL ATTRIBUTES RANKED BY FREQUENCY OF STUDY

Other includes non-significant results and results of opposite sign than expected.
Includes labs, libraries, farms, electricity, and workshops.
Source: See Annex I for a description of the individual studies.

÷.

is it possible to identify a possible impact on achievement. The data do not enable us to say if textbooks may be more important for improving reading rather than arithmetic.¹⁵

<u>Homework</u>. Students who have homework tend to do better on the achievement tests in six of the eight studies. Few of the other school determinants of achievement have as high a proportion of significant findings. This is an interesting policy variable. Since it is virtually costless in money terms, it could provide a high return. Homework, however, may be a proxy for the length of time a student spends studying, teacher training, careful supervision, or teacher motivation. If children have no books, light or quiet, then the homework might not be too effective. Again experimentation would be essential for any country wishing to explore such a policy since its actual introduction might have adverse effects among students, parents or teachers. For example, some students that have to work may not have free time for doing homework, or teachers may start using their classroom time for checking homework.

Teachers' Characteristics

Table 4 presents a summary of studies of teachers' characteristics. Of the 80 observations, 29 have statistically significant impact in the opposite direction than hypothesized.¹⁶ In each of the regions, only one-third of the cases show a statistically significant relationship with the expected sign.¹⁷ In all regions, studies have focussed on teacher education and experience, as well as on some indicators that might be proxies of quality. African studies include variables such as salary, tenure or English proficiency, while Latin American studies tend to emphasize teacher upgrading, authoritanianism, and innovations in teaching methods. Asian studies include both attitudinal variables like motivation or preparation of lessons and personal characteristics like sex or age.¹⁸

18 For a detailed discussion of determinants of teacher effectiveness, see Beatrice Avalos and Wadi Haddad, <u>op.cit</u>.

- 16 -

¹⁵ For a full discussion of class size and related issues see Wadi Haddad, op.cit.

¹⁶ U-shaped relationships may also be included as "nonsignificant". For example, dependence may be positive up to a certain point, beyond which it is negative.

¹⁷ Teachers characteristics may be related to output in non-linear ways and may operate in interaction with other variables. For example, low SES teachers may have to solve language problems and, therefore, may obtain better results when using the mother tongue with low SES children facing similar problems. Linear regression models used in the studies did not incorporate interactive terms. This is an aspect that may be further investigated.

Teacher Certification, Training and Upgrading. Thirty-two of the 80 observations about teaching attributes concern whether or not the teachers were certified. While half of the studies are statistically significant in Latin America, and in Asia, only one fourth are in Africa. The differences may reflect the educational contexts of each region. In 13 studies the presence of certified teachers in the classroom significantly affected student scores, and in 19 they did not. In the 6 studies which investigated the impact of the amount of teacher training on student test scores, only 1 was significant. A related finding concerns the upgrading of teachers; in the four studies undertaken, none showed that teacher upgrading improves the scores of students. Additional information must be obtained from each source to draw more meaningful conclusions from these studies. In the meantime, it is possible to suggest that present methods and duration of teacher training and upgrading should be reviewed with caution as a way to increase student achievement.

<u>Teacher Experience</u>. The years of experience which teachers had in the classroom was examined in 19 observations. In about one third (7 of 19) of the cases significant results with the expected sign have been obtained. The only two Asian cases are both significant, while only half are in Latin America and one fifth are in Africa. The length of teacher experience might be related to cultural traditions, or administrative procedures and incentives. A good supervisor might be associated with positive effects of a teacher's experience or with sharing of experience among teachers. If this hypothesis is true, urban teachers' experience might be more significant than the rural teachers' because of greater contact with supervisors. However, more experience might correspond with less willingness to use new methods and approaches in education. Also, older teachers with more seniority might be assigned to better schools and classes with higher performance. As before, experimentation is needed before results can be applied in decisionmaking.

<u>Teacher Turnover</u>. The rate of teacher turnover is another variable for further exploration. The two studies which have been done both found significant effects: the higher the turnover, the lower the score. It is not demonstrated, however, whether it is the change of the teacher or the time that students remain without classes because of hiring delays

	AFR		LATIN /	AMERICA	ASIA		TOTAL		
	Signif	. Other ²	Signif	. Other	Signif	. Other	Signif	. Other	A11
Educational certification	1	3	8	8	3	3	12	14	26
Experience	1	4	4	8	2	0	7	12	19
Teacher training	0	0	0	0	1	5	1	5	6
Authoritarianism	0	0	2	3	0	0	2	3	5
Upgrading	0	0	0	4	0	0	0	4	4
Sex	1	2	0	0	1	0	2	2	4
Preparation of lessons	0	0	0	0	0	3	0	3	3
Illness	0	0	0	0	0	3	0	3	3
Turnover	0	0	1	0	1	0	2	0	2
Age	0	0	0	0	0	2	0	2	2
Motivation	0	0	0	0	1	0	1	0	1
Innovation in methods	0	0	0	1	0	0	0	1	1
Tenure	0	1	0	0	0	0	0	1	1
English proficiency	1	0	0	0	0	0	1	0	1
Salary	1	0	0	0	0	0	1	0	1
Education of parents	0	1.	0	0	0	0	0]	-1
TOTAL	5	11	15	24	9	16	29	51	80

TABLE 4: TEACHER ATTRIBUTES RANKED BY FREQUENCY OF STUDY 1

1. Source: See Annex I for description of the individual studies.

2. Other includes non-significant results and results of opposite sign that expected.

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which affects students' performance. Turnover might also be a proxy for administrative red tape. The main source of problems must be identified before these results can be utilized.

Student Traits

Results for this group of variables are significant in 73 percent of the observations (48 out of 65), as shown in Table 5. There are slight differences by region - from 61 percent significant in Asia to 83 percent in Africa. Results are especially consistent for variables such as socio-economic status (SES), repetition, malnutrition, and preprimary education.

<u>Socioeconomic Status of Parents</u>. SES is the variable most frequently studied in this set. It is measured in several ways for example, by occupational scales, by educational levels, or by more complex scales. Out of a total of 13 observations, SES is a significant predictor in 10. The exception is 3 observations from a study in Ecuador.¹⁹

<u>Malnutrition and Health</u>. Malnutrition, body weight or height²⁰ and health are significant predictors of standard scores in 8 of 11 cases, a surprisingly consistent finding across studies. The finding provides strong support for experiments to raise health levels as a form of educational investment. Nutrition or health are highly correlated with SES and thus it is uncertain in those studies where nutrition and health are measured and SES is not, whether these variables are important on their own, or only an indicator of the economic status of families.

<u>Repetition of Grade</u>. Repetition has been studied in the three regions and showed that the more repeating a student did, the lower the score, in 7 observations out of 8. Repeating could be a proxy of student ability or teacher perception. Repeating could also be classified as a school attribute.²¹

<u>Television Outside School</u>. All 5 observations in the Latin American region on the effects of access to TV on achievement gave significant

¹⁹ Separate equations, however, were computed for each of six different types of schools (public urban, public rural, county urban, county rural, private religious, private other), so parts of the SES are controlled in the design of the equations.

²⁰ Measured as deviations from weight or height tables by sex and age.

²¹ Repeating may be studied as an output as well as a determinant.

TABLE 5: STUDENT ATTRIBUTES RANKED BY FREQUENCY OF STUDY 1

	AFRICA Signif Other?		LATIN AMERICA		ASIA		TOTAL		
	51gn1t.	Uther ²	51gn11.	Uther	51gn1f.	Uther	51gn1f.	Uther	AII
SES	1	0	7	3	1	0	10	3	13
Repetition	4	1	2	0	3	1	9	2	11
Malnutrition & Weight	2	0	1	0	2	1	5	1	6
Television outside school	0	0	6	0	0	0	6	0	6
Family Size	1	0	1	3	0	0	2	3	5
Health ³	3	2	0	0	0	0	3	2	5
Student Age	1	0	0	0	0	3	1	3	4
Absences	0	0	0	0	3	1	3	1	4
Kindergarten	0	0	1	0	2	1	3	ı	4
Educational Aspirations	0	0	1	1	0	0	1	1	2
Sex	1	0	0	0	0	0	1	0	1
IQ	1	0	0	0	0	0	1	0	1
Self Concept	1	0	0	0	0	0	1	0	1
Free Reading at Home	0	0	1	0	0	0	1	0	1
All pupils same ethnic group	0	0	0	0	1	0	1	0	1
TOTAL	15	3	20	7	12	7	48	17	65

1. Source: See Annex I for a description of the individual studies.

2. Other includes non-significant results and results of opposite sign than expected.

3. Includes total medical problems, blood with stool, and hospital experience.

results. However, results are not consistent with those obtained from other studies.²² Again, this variable may be a proxy for SES in developing countries.

<u>Early Child Development</u>. A major debate is underway in an increasing number of countries about the importance of early child development, between birth and school entry. Unfortunately, the studies say nothing directly about the effect of "parenting" on later learning in school. Three of the 4 observations about kindergarten attendance, however, indicate that it has a significant impact on student achievement when achievement is measured 6 to 12 years later.²³ The data on health discussed above indirectly suggest the important role of parents in contributing to child health, even when their socioeconomic status is controlled. Experiments on parent training and other pre-school factors could yield important policy results.

In short, pre-school attendance, health, repetition, and access to TV might be important policy variables. Country efforts to reduce repetition rates should be carried out, provided that the effects should be assessed. Experiments with pre-primary education should be controlled for SES and for specific social groups with special access to that level of education. In many countries, industrial workers obtain pre-primary education for their children.

Implications for Policy and Research

What policy and research implications can be drawn from the data we have presented? For policy planning, those variables that are labelled statistically significant "determinants" should be considered to be possible, but not certain, inputs to cognitive achievement as measured by school tests. This uncertainty is due to both the limitations of the cross section regression analysis and the data. The tests do not measure all aspects of cognitive achievement, nor do they measure any dimension of students' affective or interpersonal development like discipline, co-operation, responsibility of leadership. And it may be these traits which schools can foster through the curriculum that may have a greater impact on the earnings

22 Robert C. Hornik, "Television Access and the Slowing of Cognitive Growth" in <u>American Educational Research Journal</u>, Winter 1978, Vol. 15, No. 1 pp 1-15.

23 IDRC is sponsoring an experimental project on the relationships between primary training and first grade outcomes in four Latin American countries.

- 21 -

and satisfaction of adults, than their cognitive skills.²⁴ The results, however, should encourage planners and educators to undertake pilot projects (to study the effects in their own countries of increasing class size, initiating homework, and improving early child development, for example).

In brief, our review indicates that a small number of determinants should have priority for experimental research compared to the large pool which were assumed to be equally important when the review was undertaken. The experiments should use the students, the classroom and the school as the unit of observation to capture effects which may have been omitted or under-estimated in earlier studies. We should also note that some attributes like intelligence, self-concept, teacher motivation and parent education for early child development have not been widely studied in their relation to student achievement, thus they should not be out of consideration for future research for this reason.

About half of the observations (12 out of 242) reported in Table 6 are statistically significant determinants of school achievement.²⁵ Within the 123, however, variables related to student characteristics seem to provide more consistent results than either teacher or school characteristics. While 73% of the observations are significant in the expected direction for student characteristics, only 48% of the school characteristics and 36% of teachers' characteristics are significant. While these results suggest that school effects may be less important than we expected, the main result is the selection of a small but important set of variables that are most promising for further examination.

The set of student characteristics present particular problems for generating a suitable change, since they are not easily affected by education policy. Relationships between SES and the rest of the indicators must be more clearly defined before support for specific actions can be

²⁴ The relationship between affective and interpersonal traits fostered by schools and their impact on earnings, productivity and satisfaction has been ignored in the empirical research for developing countries. For a review of American data see Herbert Gintis, "Technology, Work and Education", <u>American Economic Review</u>, April 1972.

²⁵ Nearly all studies include at least one variable in each of the three attributes.

- 23 -TABLE 6: SUMMARY OF THE DETERMINANTS (number of observations)

	Significant	Other	Total	Percentage Significant
School Attributes	47	51	98	48
Teacher Attributes	29	51	80	36
Student Attributes	47	17	64	75
All Attributes	123	119	242	51

obtained from the studies. They are not, however, promising variables to be affected by policy instruments either to increase achievement or reduce costs. In the other two sets of characteristics, most of the variables are related to policy decisions. The results, however, are mixed and in several cases the variables might act as proxies of other dimensions of the educational process, rather than being important themselves. The results of each study must be examined in terms of the context of each country.

We have compared the results of the review in 1974 and 1978 in table 7. In 1974, there were a total of 61 observations, in 1978, there were 242. The percentage of both school and teacher attributes which were significant has declined. This discouraging result, however, does not reflect changes in what is happening in the schools. Rather, because the later review is a larger sample, it is a more accurate picture of what has been taking place all along. The 1978 review is still an imperfect sample of schools in developing countries. Traditions, attitudes, teachers' prestige, expectations created by educational certification, student and parental aspirations and many other variables affect the impact of the variables. Subjective judgment of the results in each country must supplement direct experimentation.

Two lines of future work are needed for the selection of the more important variables for policy making. First, the most strongly supported relationships among the school characteristics are the most promising in terms of either increasing achievement or reducing costs. Their real influence should be assessed through carefully designed pilot projects

	Percen Signif	tage icant	Numbe Observ	r of <u>ations</u>	
	1974	1978	1974	1978	
School Attributes	59	48	27	98	
Teacher Attributes	54	36	28	80	
Student Attributes	100	73	6 ¹	64	

TABLE 7: COMPARISON OF 1974 AND 1978 REVIEWS

Sources: For the 1974 review, Simmons and Alexander's Table 2, p. 350, <u>op.cit</u>., and for the 1978 review, tables 2, 3, and 4 above.

1. The Simmons and Alexander review focusses on the School and Teacher Attributes in each study; thus 6 is not an accurate account of the number of student attributes actually measured in those studies.

and controlled experiments.²⁶ Two illustrations of promising experiments are underway in Nicaragua and the Philippines to examine the effects of radio and textbooks on achievement.²⁷ Second, available data on some of the studies should be reanalyzed to obtain more meaningful comparisons. For example, the classroom as a unit of analyzing seems to be more suitable than the student for testing teacher effects, if the teacher is dealing with the class group as a whole. Attention to factors affecting achievement of low SES students should be a priority, given the evidence from Thailand for example, which suggests substantive differences between effects of variables on different SES levels. This is supported by analysis of United States and Latin American data. Rural and urban differences should also be explored. Work is also needed to standardize the definitions used for similar variables, as well as to discuss the policy implications of the statistical methods, like path analysis and longitudinal data sets used for estimating parameters. Finally, cross tabulation and residuals might be computed for studies with large samples to study high performing schools for non-linearities or threshold effects.

²⁶ In order to carry out experiments, a previous step might be useful. For most relationships, other types of approaches have been implemented. For example, teacher-student interactions have been analyzed from many points of view and the same has happened for reading or writing. Available knowledge in developing countries related to the variables selected for experiments should be summarized for use in the design of the experiments.

²⁷ World Bank Education Loan V to the Philippines, 1977, and Dean T. Jamieson "Radio and Student Repetition in Nicaragua", in P. Suppes, B. Searle, J. Friend, Eds., <u>The Nicaragua Radio Mathematics Project, 1975-76</u> (Stanford, Ca: Institute for Mathematical Studies, 1978).

In conclusion, multivariate studies have provided major ideas for policy and research in developing countries by initiating a screening process. Approximately ten variables from more than 500 have been identified for further examination. The next step is to undertake experimental studies assessing their impact as policy variables on cognitive achievement and other educational outcomes like affective and interpersonal development.

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DETERMINANTS OF SCHOOL ACHIEVEMENT: AFRICA

Expected Stat. Not Signif. Variable Sign Signif. or Opposite Sign SCHOOL ATTRIBUTES 1) Per pupil expenditures on school facilities or teachers (+) Thias-Carnoy (gr. 7) 2) School facilities Availability and use of library (+)Heyneman et.al. School electricity Heyneman et.al. (+) (4) School farm Heyneman et.al. 3) Textbook availability at primary grades (‡) Heyneman et.al. 4) Size of school enrollment at upper secondary grades (+) Thias-Carnoy Youdi (gr.11) (-) 5) Average class size or pupil/teacher ratio Thias-Carnoy (gr.7) 6) Homework and free reading at home (+) Simmons 7) Performance and attitudes of classroom (+) Carnoy-Thias peer groups 8) Boarding at secondary grade (+) Thias-Carnoy (gr. 11) Carnoy-Thias Youdi (4) Boarding at gr. 7 Heyneman et.al. TOTAL 8 6 TEACHER ATTRIBUTES 1) Teacher certificate and academic qualification Thias-Carnoy (gr.7) at primary and lower secondary grades (4) Heyneman et.al. Teacher certification and academic gualification (+) Youdi at upper secondary grades 2) Teacher experience at primary & lower secondary Carnoy-Thias (+) grades Youdi 3) Teacher sex-males at primary & lower secondary Carnoy-Thias Thias-Carnoy (gr.7) (+) grades; females at upper secondary levels Youdi 4) Jeacher contract (tenure) at upper secondary grades (+) Carnoy-Thias (+) 5) Teacher's English Heyneman et.al. 6) Teacher Salary Grade (4) Heyneman et.al. 7) Education of teacher's parents (+) Heyneman et.al. TOTAL 5

Annex I Table 1 page 1 of 2

11

Annex I Table 1 page 2 of2

	<u>Variable</u>	Expected Sign	Stat. <u>Signif.</u>	Not Signif. <u>or Opposite Sign</u>
\$TUC	ENT ATTRIBUTES			
1)	SES	(+)	Heyneman et.al.	
2)	Grade repetition	(-)	Thias-Carnoy (gr. 7) Simmons Youdi Heyneman et.al.	
	No. years dropped out of school	(-)		Heyneman et.al.
3)	Malnutrition	(-)	Heyneman et.al.	
	Amount of Breakfast Eaten	(+)	Heyneman et.al.	
4)	Age	(-)	Heyneman et.al.	
5)	Health	(+)	Heyneman et.al.	
	Pupil Hosp. experience	()	Heyneman et.al.	
	Blood with stool	()	Heyneman et.al.	
	Total medical problems	(_)		Heyneman et.al.
	Disease	(–)		Heyneman et.al.
6)	Sex	(†)	Heyneman et.al.	
7)	Intelligence	(+)	Heyneman et.al.	
8)	Pupil Self-Concept	(†)	Heyneman et.al.	
9)	Position in Family (family size)	(+)	Heyneman et.al.	
		TOTAL	15	3

Annex 1 Table 2

DETERMINANTS OF SCHOOL ACHIEVEMENT: LATIN AMERICA

Variables and Expected Sign of it's Relationships to Students Performance	Statistically Significant With Expected Sign	Not Statistically Significant, or With Opposite Sign
TEACHER VARIABLES		
<pre>1) teacher certification (+) (education)</pre>	Rivarola (4th & 6th grades) Echart et.al.(secondary) Costa (R&M) Purves (11-Lit) Klees (74) Comber (IV Se)	Rivarola (secondary) Echart et.al. (4th & 6th) Wolff (70) Munoz (71) Schiefelbein-Farrell (70) Purves&V-Lit);Carroll IV-Frenc
2) teacher experience (†)	Swett (6th grade) Rivarola (4th & 6th grades) Costa (M)	Swett (1st & 4th grades) Rivarola (Secondary) Echart <u>et.al.</u> (all) Klees (74);Carroll(IY-French)
3) teacher turnover (-)	Wolff (70)	
4) teacher upgrading (+)		Echart et.al. (all) Schief-Farrell (70)
5) teacher authoritarianism	Rivarola (6th grade) Swett (6th grade)	Rivarola (4th grade) Swett (1st & 4th grades)
6) innovation in teaching methods (+)		Echart <u>et.al</u> . (all)
TOTAL	15	24
SCHOOL VARIABLES		
1) average class size (→) (pupil:teacher ratio)	Swett (4th & 6th grades)	Swett (1st grade) Schief, & Farrell (69)Echart et.al, Schief, & Farrell (70)
2) school facilities availability (+)	Echart et.al. (6th grade) Munoz (71)	Echart <u>et.al.</u> (4th grade & secondary)
3) school year length (+)	Schief. and Clavel (72-74)	
4) double sessions (-) (double shifts)		Schief. & Farrell (70)
5) coed. student body (+)		Schief. & Clavel (72-74) Schief. & Farrell (70)
6) extracurricular activities (+)	Munos (71)	
7) study at home (+)	Costa(m); Comber & Keeves (1¥)	Comber & Keeves (1 & 11)
8) textbook availability (+)	Wolff(70) Schief. & Farmell (70)	
9) expenditure per pupil (+)	Swett (1st, 4th & 6th)	Swett (1st, 4th & 6th)
10) library utilization (+)		Costa (R&M)
TOTAL	14	18
STUDENT ATTRIBUTES		
1) free reading at home	Schief. & Farrell (70)	
2) kindergarten (+)	Wolff (70)	
3) T.Y. (+)	Costa (R&H) Schief. & Farrell (70) Schief. & Clavel (72-74) Costaneda <u>et.al</u> .	· · · · · · · · · · · · · · · · · · ·
4) SES (+)	Costa (R&M); Swett (4th & 6th) Schief. & Farrell (70) Schief. & Clavel (72-74)	Swett (1st, 4th & 6th)
5) family size (~)	Costa (R)	Costa (N) Schief, & Clavel (72-74)
6) repetitions (-)	Costa (RBM)	
7) education aspirations (+)	Costa (M)	Costa (R)
8) malnutrition (-)	Schief. & Farrell (70)	
TOTAL	20	7

DETERMINANTS OF SCHOOL ACHIEVEMENT: ASIA

Annex 1 Table 3 Page 1 of 2

Variables and Expected Sign of it's Relationships to Students Performance	Statistically Significant With Expected Sign	Not Statistically Significant, or With Opposite Sign
TEACHER ATTRIBUTES		
1) teacher education (+) (amount of post- secondary for IEA)	IEA India (Science Pop.11)	Fuller & NEC (students from low, middle and upper income families)
		IEA Thailand (Science Pop. IV)
		IEA Iran (Science Pop. IV)
2) teacher experience (+)	Beebout Haron	
3) teacher motivation (+)	Ryan	
4) teacher qualification (4)	Fuller & NEC (low income) Beebout Haron	Fuller & NEC (middle and upper income) Ryan
5) teacher preparation (†)		IEA India (Science Pop. IV)
of lessons		IEA Iran (Science Pop. IV)
	· · · · · · · · · · · · · · · · · · ·	IEA Thailand (Science Pop. 19)
6) transfer rate of teachers (+)	Haron	
7) teacher age (+)		Fuller & NEC (middle and upper income)
8) teacher absence ()		Fuller & NEC {low, middle and upper income
9) teacher sex (4) (males at primary and lower secondary, females at upper secondary)	Beebout	
TOTAL	12	13
SCHOOL ATTRIBUTES	· · · · · · · · · · · · · · · · · · ·	
1) pupil:teacher ratio (=)	Beebout Ryan Haron	Fuller & NEC (lower, middle and upper income students)
2) distance time to school (-)	Fuller & NEC (low & middle income)	Fuller & NEC (upper income)
3) total time devoted to science study and homework (†)	IEA India (Pop. IV)	IEA Thailand, (Pop. IV) IEA Iran,(Pop. IV)
4) total years study of science (+)	IEA India (Pop. Science IV)	IEA Thailand (Pop. Science)
	IEA Iran (Pop. Science IV)	IEA Thailand(Fop. Scien. IV)
	IEA India (Pop. Scien. 11)	IEA India (Pop. Science II)
	IEA Thailand(Po. Scien II)	IEA Iran (Pop. Science II)
5) school size (+)	Fuller & NEC (low, middle	Bec bout
	IEA Iran. (Pop. IV)	IEA India (Pop. IV)
		IEA Thailand (Pop. IV) Haron
6) boarding at secondary (+)		Beebout
7) double sessions (-)	Beebout	
8) space per pupil in classmon (4)		Fuller & NEC (lower, middle

Annex I Table 3 Page 2 of 2

Variable and Expected Sign of it's Relationships to Student Performance	Statistically Significant With Expected Sign	Not Statistically Significant, or With Opposite Sign
9) availability of textbooks (†)	IEA India (Pop. I Science) IEA Iran (Pop. I Science)	
	Fuller & NEC (lower, middle and upper income) Beebout Haron	
10) hours of homework per week (†)	IEA India (Pop. II Science) IEA Thailand(Pop. II Science) IEA Iran (Pop. II Science)	
11) per student experience (†)		Beebout
12) availability & use of library (+)	Beebout Haron	
13) percent of teachers of science (47)		IEA India (Pop. II Science) IEA Thailand (Pop. II Science) IEA Iran (Pop. II Science)
(4) student-made science observations & experiments (47)	IEA Iren (Pop. I Science)	IEA India (Pop. 1 Science) IEA Thailand (Pop. 1 Science)
TOTAL	25	33
PUPIL ATTRIBUTES		
1) student age (4)		Fuller & NEC (lower, middle and upper income)
2) repeated grade (†)	Fuller & NEC (lower, middle and upper income)	Beebout
3) attended kindergarten (4)	Fuller & NEC (middle and upper income)	fuller & NEC (lower income)
4) weight (j)	Fuller & NEC (low and middle income)	Fuller & NEC (upper income)
5) pupil absence record (-)	Fuller & NEC (low and middle income) Haron	Fuller & NEC (upper income)
6) 100% pupils same ethnicity (-)	Haron	
7) SES 1	Fuller & NEC (pooled data)	
	12	7

1. The IEA studies don't report their SES findings in regression form. See p. 196 of Comber and Keeves for example.

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