How Much Do Schools Matter to Pupil Achievement in India?

by

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Abstract

Are school characteristics more important to student achievement than pupils' home background? We are provoked to address this question because of Heyneman and Loxley's (1982, p18) dramatic conclusion that in India, the overwhelming proportion (90%) of the variance in students' science achievement is explained by school and teacher variables and only a small proportion (10%) by home factors. Our findings fail to confirm Heyneman and Loxley's result for India but suggest, instead, that home background and school influences are both important to student achievement in India.

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I Introduction

Recent findings that cognitive achievement is statistically important in determining workers' productivity[1] suggest that pupils' school achievement has important implications for economic growth. This recognition of the economic importance of student learning has led to attempts, both in India and internationally, to understand better the determinants of student achievement.

The research in this paper addresses for India the policy question initially asked a quarter century ago within developed countries, namely, do schools matter in shaping the academic achievement of students? Large scale studies in UK (Plowden Report 1967, Peaker 1971) and USA (Coleman Report 1966) sought to discover the aggregate influence of school quality on achievement after empirically controlling for pupils' family background. Their common conclusion that differences in schools had no significant impact on student achievement was largely corroborated by a large-scale study of science achievement in 19 high and low income countries conducted for the IEA by Comber and Keeves (1973) and of reading achievement in 15 countries by Thorndike (1973).

The conclusion that students' achievement was overwhelmingly determined by home background factors in developing as well as developed countries was challenged by Heyneman and Loxley (1982, 1983)[2] who resubmitted the IEA data to a new process of variable selection to find that, whereas in developed countries, home background of students mattered much more to achievement than school quality, the reverse was true in low income countries.

Given this background, it is of particular interest to address the above question for India, particularly because of Heyneman and Loxley's (1982, p18) dramatic finding that, of the variance in science achievement that can be explained in India, 90% is attributable to school and teacher quality and only 10% to home factors. They concluded that 'the statistical effect of school and teacher quality is higher in India than in any other country in the world on which there is data'.

The present paper examines the institutional (school and teacher) as well as home background factors that boost student achievement in India. The analysis has a two-fold purpose. Firstly, it allows us to test statistically for the importance (to pupil achievement) of institutional variables that are typically viewed as indicators of school quality both in India and elsewhere, such as class size and teacher training, education, experience, and salary. Secondly, it asks the more traditional question: do school and teacher factors matter more to pupil achievement than home background factors? This is of interest because of Heyneman and Loxley's (1982, p18) dramatic finding that in India, the overwhelming proportion (90%) of the variance in students' science achievement is explained by school and teacher variables and only a small proportion (10%) by home factors. We re-examine the issue with richer data on students' home background than was available to Heyneman and Loxley.

The data for this study were collected from 902 children aged 13-14 years old in a sample survey of 30 schools in urban Lucknow in Uttar Pradesh, India in 1991. The survey collected data on all children enrolled in any one section of class 8 in the sample schools. Each sample pupil took 2 cognitive skill tests, one in numeracy and the other in literacy. These were adaptions of tests prepared by the Educational Testing Service, Princeton, NJ. It also collected information from school authorities and from teachers *who taught the sample students,* rather than all teachers of the sample schools. The survey and data are described in detail in Kingdon (1994).

Section II examines which specific institutional factors are the most important in boosting student achievement, controlling for pupils' home background. Section III focuses on whether school quality, as a block, is more important to student learning than home background and personal endowments in India. The last section concludes.

II Institutional determinants of student achievement

School quality varies dramatically in India. In terms of 'output' of education, the best products of Indian schools compete at the world level in projects such as the international mathematics olympiad, while the worst may complete high school without much other than a poor ability to read, write and do simple arithmetic. In terms of inputs, the disparities are most conspicuous in physical facilities and teaching materials from high resource schools with excellent facilities to single-teacher schools with no building, drinking water, toilets, blackboard, electricity, furniture, charts or library (GOI 1985). Given these facts and the possibility that teacher characteristics and school organisation may also vary greatly, it is expected that institutional influences on pupil achievement will be strong. In this section, the focus is on identifying *which* particular school and teacher factors influence student achievement most significantly.

IIa Estimation issues

Ideally, any exercise to investigate the determinants of student achievement should take into account the selectivity of children enrolled in particular grades. If a sample of pupils in class 8 (aged 13-14 years) is unrepresentative of the population of all children in that age group - due to the drop-out of less motivated children - then the estimated coefficients of the achievement function will suffer from endogenous selection bias. This type of bias could well be a problem in Indian data where, despite statutory compulsory schooling up to age 14, early school drop-outs are common[3]. Unfortunately, however, our data do not permit us to employ corrective procedures for any such potential bias: since our data were collected from enrolled students only, we are unable to estimate the probability that an individual will appear in the sample.

Given this data inadequacy, we draw comfort from two recent studies (Glewwe and Jacoby 1993 for Ghana and Harbison and Hanushek 1992 for rural Brazil) both of which find selectivity of students who survive to (attain) a particular level of education is statistically insignificant in achievement functions. However, although selectivity in school survival was not a problem in the particular datasets used in the Ghanian and Brazilian studies, we do not dismiss it as a possibility in Indian data.

Achievement production functions are employed to fit three regressions, one each for maths, reading, and achievement (maths+reading) test scores. The independent variables or inputs into the educational process fall into one of five categories: characteristics of students and of their families, peergroups, teachers and their school. Our purpose-designed data allowed us to test the importance to achievement of a large number of independent variables[4].

IIb The results

Table 1 gives the definitions, means and standard deviations of variables. Table 2 presents the estimated results for major sets of inputs - students, households, peers, teachers and schools. The maximum possible score in the maths and reading tests was 36 and 29 respectively. Thus, the maximum possible achievement score was 65 points.

Before turning to the results of the above model, some estimation issues bear discussion. It is possible that the model in Table 2 is misspecified since it takes no account of school-type. We have the prior belief that school management-type influences pupil achievement importantly. For example, Kingdon (1996) found that private unaided (*PUA*) schools are better quality than government-funded (*GPA*) schools and, similarly, Govinda and Varghese (1993) found that private schools are better quality than government schools.

Thus, ignoring school-type in the achievement production function may cause omitted variable bias in the estimated parameters of the model in Table 2. Accordingly, we investigated two ways of taking school-type into account. The first method, consistent with Govinda and Varghese (1993) was simply to include a school-type dummy, namely the *PUA* school dummy, in the OLS regression model for achievement. The results of this model are reported in appendix 1. Consistent with Kingdon (1996) and Govinda and Varghese (1993), we find that attending a *PUA* school is strongly associated with higher achievement. That is, even after controlling for measured pupil, household, peergroup, teacher, and school variables, school management-type is an important influence on student achievement.

It should be noted that the school-type dummy in the achievement regression in appendix 1 may not be exogenous since parents may choose particular school-types on the basis of expected achievement in them (see Kingdon 1994, 1996). Thus, in order to investigate the effect of school-type on student achievement, a treatment effects model was estimated using non-linear two stage least squares (Greene 1993 p713 and Greene 1992 p609-610). This method takes the endogeniety of the school-type dummy into account, using the probability of selection into a *PUA* school (Z) as an instrument for the *PUA* dummy. Three specifications of this model are presented in appendix 2.

Discussion of results

In the treatment effect model of Appendix 2, none of the specifications allowed us to identify the coefficient on the endogenous dummy. We experimented with a number of specifications both of the probit and of the achievement equation but the Z variable could not be identified. Doing the same with maths and reading achievement functions gave poorly determined estimates of the coefficient on Z. In all alternative specifications with which we experimented, the point estimate of the coefficient on the instrument was imprecise. In some cases, it even took a value higher than the OLS estimate. It is clear that there is a substantive relationship between the point estimate on the instrument and the point estimates on the two variables *AVSALARY* and *ADIVISIO*, and this reflects the identification issue.

In comparing table 2 and Appendix 1, the inclusion of the *PUA* school dummy has little effect on most of the reported coefficients, except for those on *AVSALARY* and *ADIVISIO*[5]. Since it is only the coefficients on *AVSALARY* and *ADIVISIO* that are much affected by the inclusion of the *PUA* school dummy, it is only in the case of the effect of these two variables that the issue of distinguishing between Table 2 and appendix 1 mainly arises. The results on the other variables are fairly robust to the inclusion of the school-type dummy. We base our discussion on the results in Table 2 but the large, positive effect of the *PUA* dummy should be borne in mind; moreover, it should also be borne in mind that the true effect of *AVSALARY* may be larger and statistically more significant than that implied by the results in Table 2 and similarly, the true effect of *ADIVISIO* may be somewhat smaller and less significant than that implied in Table 2.

Student characteristics: Ability, as measured by the score on the Raven's Progressive Matrices test (*SRAVEN*), is highly important in explaining variations in achievement. Male students perform significantly better than female students in both skill areas. Pupils' age (*CHAGE*) and number of hours of home study per week (*HSTUDY*) both have the expected signs, indicating that longer home study enhances learning, particularly in maths, and that age reflects the negative influences of low motivation and grade repetition. Travel time to school (*TRTIME*) has a positive if small influence on achievement, reflecting perhaps that those who are willing to travel further, attend better schools. Those who take private home tuition (*TAKESTU*) do worse than other pupils, though not significantly so. This suggests reverse causation, namely that low achievers compensate by buying increased instruction outside of school.

Household characteristics: The impact of family's economic status, as measured by the *WEALTH* variable, is equally important for maths and reading skills. Pupil achievement is significantly concave in *WEALTH*. *LOWCASTE* pupils have significantly lower achievement than their non-lowcaste colleagues even after controlling for parental education and household wealth. Number of siblings (*NUMSIB*) in the family exerts a strong negative influence on achievement in all three regressions, lending support to the hypothesis of a child quantity-quality trade-off: the greater the number of siblings in the family, the less the parental attention to any one child. Interestingly, parents help with studies at home (*PARHELP*) had a consistently negative association with achievement in both skill areas. This result, like the one for home tuitions, suggests a reverse causality interpretation. Parents help children who have low achievement.

Peergroup characteristics: In choosing peergroup variables, the intention was to focus on those which related to the way school authorities organised classes. Percentage of females in sample class (*PEERFEM*) and the ability mix of the class (*VARAVEN*) are both potentially manipulable. A third peergroup variable *GIRLSC* (girl student in an all-female school) has also been included in the regressions to test if girls benefit academically from being in single-sex schools. The results are interesting. Pupils' reading skills are not influenced by the gender-mix of the class but their maths skills are strongly affected.

The coefficients on *PEERFEM* and *GIRLSC* were robust to changes in the specification of the regression equation and may be interpreted as follows: Boys' do better in maths as *PEERFEM* rises but not girls. Moreover, under complete segregation, girls perform significantly worse in maths than under coeducation. This result does not conform to the received wisdom in many societies that academically girls perform better in single-sex classes and, as such, it merits examination. The most plausible explanation of our finding is that in the sample district, girls' schools may not emphasise maths learning in class 8 as much as boys' and co-educational schools, probably because most girls who continue education after class 8 opt for arts and humanities subjects in high school. Many girls' secondary schools do not even offer a maths and science curriculum in high school classes[6] and this would have a bearing on the emphasis they place on maths learning in class 8. The ability mix of the class, as measured by *VARAVEN*, has a negative influence on achievement in both skill areas, but significantly so only in reading skills. We surmise that grouping together children of widely varying abilities is detrimental to achievement in reading skills.

Teacher characteristics: Observe the impact of teacher characteristics on the overall achievement of students in Table 2. Of the five teacher variables included, *ADIVISIO*, the proxy for quality of education of teachers, is the only variable that has a strong, statistically significant impact on pupils' overall achievement scores. Teachers' education comes close to being significant at the 10% level. All other teacher variables normally used as proxies for the elusive concept 'quality of teaching' are unimportant in explaining variations in achievement scores. In terms of quantitative importance, an increase of one standard deviation in teachers' (average) education, training, experience, salary, and division above the mean values would change student achievement by 0.45, 0.19, -0.19, 0.42, and 1.12 points respectively. That is, division - the proxy for teachers' own cognitive skills - is the most important teacher attribute, though it should be noted that its effect on achievement may be somewhat overestimated in Table 2, as discussed earlier.

The results of the teacher variables do not provide support for the belief that teacher training, experience and, to some extent even post-graduate education[7], are good indicators of teachers' effectiveness in imparting cognitive skills to students. It appears that differences in the quality of education of teachers may be sufficiently large to obscure most effects of 'quantity' differences.

School characteristics: Cognitive skills acquisition of students benefits systematically and strongly from schools' improved physical and teaching facilities (*RESOURCE*) as well as from longer interaction with teachers (*NMINACAD*)[8]. These results are educationally reasonable and are corroborated by findings in most developing countries on which educational production function studies exist (see Fuller 1986 p26-27). Moreover, as the specification with the *PUA* school dummy shows, school management-type also has a large and statistically significant effect on student-learning. This suggests that the management practices of *PUA* schools - such as decision-making at the school-level, close monitoring of teachers' work, and requiring regular teacher attendance - profit stuents. This importance of school management-type for pupil achievement is confirmed by a model of student achievement which takes into account endogenous sample selection of students into the different school management-sectors using the familiar Heckman correction (see Kingdon 1996).

Class size or pupil teacher ratio (*CLNUM*) has no significant relationship with overall student achievement[9]. The effect of pupil-teacher ratio on maths and reading achievements separately is interesting. Whereas larger classes are detrimental to the acquisition of numeracy skills, they are very conducive to improving literacy skills. This result suggests that rote learning prevalent in language classes in many schools profits students but that learning maths requires individual attention of the teacher.

In terms of the quantitative importance of school factors, a one standard deviation increase (above the mean values) in class size, length of instruction, and resources - one at a time, while holding all other variables at mean values - would increase student achievement by 0.29, 1.66, and 2.53 points respectively. This suggests that changes in school resources and materials and the length of the school week are by far more important to student learning than changes in class size.

Conclusions: Of all the institutional variables, the ones that affect student achievement most are school resources, length of instruction time per week, school management-type (that is, private unaided or not), and teachers' own cognitive skills. However, class-size, teacher training, teacher experience, and even - to some extent - years of teacher education, are not important to student learning in our data.

IIc Comparison with findings in other studies

Comparison with studies in India

In India, there are two strands of statistical evidence on the determinants of school quality, as proxied by student achievement[10]: (i) a recent study using survey data from Madhya Pradesh (Govinda and Varghese 1993), and (ii) three studies using IEA[11] 1970s data collected by postal questionnaires (Heyneman and Loxley 1983, Comber and Keeves 1973, and Thorndike 1973). Govinda and Varghese's study finds that school management-type (government or private school) and teacher education are the only 2 institutional variables that are significant determinants of pupil achievement. Unfortunately, the authors do not discuss whether they tried including variables such as teacher experience and class size but dropped them due to their insignificance. However, their result on the superior achievement of private school students corroborates our findings in appendix 1, though the use of the school-type dummy is methodologically suspect as discussed earlier.

Our results on the importance, to student achievement, of school materials and facilities, instructional time, and class size are confirmed by the IEA studies (see Table 3) but not the results on the effect of teacher variables on student achievement.

Comparison with studies internationally

Fuller (1986) reviews 72 empirical studies of student achievement worldwide and extracts results on which individual elements of school quality are statistically significant in explaining pupil achievement at the 5% level. Those which are significantly related to achievement in at least half of the studies are assumed to hold a 'consistent' influence on achievement. Fuller's review shows that class size and teacher salary are not consistently related to achievement but that length of instructional time, teachers' tertiary training and availability of instuctional materials are. Fuller's conclusions from LDC studies are partly corroborated by Hanushek's (1986) review of 147 educational production function studies in industrialised countries which finds that variations in pupil-teacher ratios (class size) and in teacher education, experience and salaries do not explain variations in pupil achievement. Thus our results from Indian data are in satisfyingly close conformity with the distilled results from studies worldwide.

IId Conclusions

The findings of this section have worrying implications. They suggest that in India the specific inputs into education that determine quality may be poorly identified, as Behrman and Schneider (1992) fear. Though officials are right to document, monitor, and seek to improve the level of school facilities and teaching materials in an effort to upgrade school quality[12], much of the rest of educational data, discussion, and expenditure in India has been on measures of quality that, according to our survey, are dubious indicators such as class size (pupil -teacher ratios), teachers' training and experience, and possibly, even teachers' education and pay. Our analysis suggests that school administrators should, invest, instead, in strengthening school-management and teacher monitoring (as in *PUA* schools), in recruiting teachers with better cognitive skills, having better school facilities/teaching materials, and in longer instruction times.

III How much do schools and teachers matter in India?

As stated in the introduction, this issue was addressed in a number of early studies. For example, for USA see the Coleman Report (1966); for UK, the Plowden Report (1967); and for international comparisons, Comber and Keeves (1973) and Thorndike (1973). Subsequently, Heyneman and Loxley (1982, 1983) revisited the issue in the early 1980s with some methodological improvements over the earlier studies, and overturned (at least for developing countries) the previous studies' pessimistic conclusion that variations in school and teacher characteristics mattered little to student achievement, which was determined predominantly by home background. All these studies were concerned with examining whether school-related factors (as a block) were a more important influence on student achievement than home-background characteristics (as a block).

The only study in India which we have found that addresses this issue is Subrahmanyam (1984). This examines the question of the relative influence of school and home on reading achievement with early 1980s data on 300 students in 15 primary schools in Andhra Pradesh. Using principal-component analysis, it concludes that, in all, school factors account for 61% of total variation in achievement and home background factors explain 39%.

In Heyneman and Loxley's (1983) study, which uses the production function approach like ours, 30% of the variation in science achievement is 'explained'[13]. Only 3% is explained by pupils' home background and 27% is explained by school and teacher quality variables. They state (p 1174) that "no effort has been made to separate the common variance shared among the regression blocks. By virtue of the pre-school [i.e. pupil-background] variables always being entered first into the individual country regressions, all common variance is subsumed by pre-school variables; this amounts to a conservative bias against school effects". This means that when only the pre-school, *i.e.* pupil and home background, variables are entered into the regression, only 3% of the variance in science scores is explained (R^2=0.03) but that when school and teacher variables are added, R^2 goes up to 30%. When we follow a similar procedure in our regressions, the results are as given in Table 4. The achievement regressions with just pupil-background variables are given in Table 5 and the regressions with just school variables are given in Table 6.

Table 4 shows that in our data, most of the explained variation in achievement scores is due to pupil-background variables and only relatively little is attributable to school, teacher and peer variables. Given that this result is directly opposite to the findings of Heyneman and Loxley (H&L), an attempt at reconciliation would aid a clearer understanding of the determinants of achievement in Indian schools. The following observations go some way towards explaining why the two findings may differ so much.

IIIa The importance of home background variables

Why do H&L's pupil-background variables explain only 3% and ours up to 59% of total variation in achievement scores? The student and family variables used in the statistical analysis in this study capture household socio-economic status and home educational environment more fully than H&L's data. In the latter's study, the background variables were pupils' age in months, sex, and family's socio-economic status (SES) as proxied by some of the following variables (we do not know which specific ones were used for India because regressions for each of the 29 different countries used different SES variables depending on statistical significance): mother's and father's education, father's occupation, number of books at home and presence at home of a phonograph. Our data has a much more extensive measure of family's economic status (*WEALTH*) than H&L's measure. In all of our regressions, the *WEALTH* variable is highly significant.

In our regressions, father's occupation and education are not significant and mother's education as well as number of books at home are only marginally significant. Most of the household variables that are significant in our regressions reflect home educational environment rather than SES *per se*. Variables such as *NUMSIB*, *PARHELP*, *LOWCASTE* and *MUSLIM* were not available to H&L. Moreover, H&L did not include many of the students' personal characteristics which are highly important in our regressions such as a measure of ability, child's educational aspiration, whether student works to earn money, hours of home study per week, travel time to school and whether student takes private home tuitions. When we regress student achievement on child's age, sex and number of books at home (dummies), $\overline{R}^2$s are only 0.126, 0.121, and 0.096 in the achievement, maths, and reading regressions repectively.

There is a further, technical, point. In H&L's study, if there were missing values on a household variable for 25% of the observations, then the average value of the variable was assigned to the missing values. We do not know if the incidence of this phenomenon was large but the effect of such treatment would be to reduce variation in home background variables and thus render them less capable of explaining variations in the dependent variable.

Finally, the explanatory power of pupil-background variables in our equations relative to their explanatory power in H&L's study may be because we have classified certain variables as pupil and home-background variables that are also partly influenced by schools and teachers. For example, a child's educational aspirations may to some extent be moulded by the school; hours of home study per week may reflect the combined influence of parental motivation and school home-work setting policy[14], travel time to school may be mimicking the effect of school quality, with those who are prepared to travel further attending better schools; wealthier students may choose better quality schools. Thus, some of the explanatory power being attributed to home background may actually belong in the school/teacher quality block.

In sum, pupil-background variables explain a very large proportion of the total variation in achievement in the present study because our rich dataset allows us better to capture important aspects of the home educational atmosphere and pupil characteristics which influence achievement and because certain variables which are affected by school/teacher quality have been classified as home influences.

IIIb The importance of school variables

Why may school (non-pupil) variables explain 27% of variation in achievement in H&L's study and as little as 6.8% in ours when we follow the same method as in H&L? The main reasons for this discrepancy between our results and those of H&L are that

- H&L's study, with data on a much larger number of schools[15], has greater variation in school and teacher characteristics than our study with data only on 30 schools. This also means that in H&L's study, a larger number of school variables could be included[16]. In other words, H&L's *school level* data is better than ours;
- The impact of pupil-background variables has not been adequately taken into account in H&L's research due to data deficiencies;
- Although H&L think it unlikely, their school and teacher quality variables may pick up some of the unmeasured effect of home background on achievement, since home background and school quality are highly correlated in Indian society;

In the data for the present study, there is fairly clear indication that children from privileged home backgrounds attend more high resource schools and schools with longer instruction times and are exposed to better quality teachers, as seen from Table 7.

A comparison of the coefficients in the regressions with and without school variables (see Tables 2 and 5) clearly suggests that school quality and socio-economic status are related enough to make it difficult to separate statistically their two influences on achievement. Omission of school variables (Table 5) leads home background variables to 'pick-up' the former's influence and appear very significant. When school variables are added (Table 2) the coefficients and significance of background variables fall. Similar effects are observed if only school variables are regressed first (see Table 6) and then background variables are included. There is no *a priori* theoretical basis for dividing up the large common variance shared by home background and school quality.

Our results challenge H&L's conclusion that in India school factors are by far the most predominant influence on student learning and that home factors have only a small effect. The results suggest that, due to the inadequacy of data on pupils' personal and home background characteristics, H&L's study greatly underestimates the contribution of home factors and overestimates the relative contribution of school factors in student learning *in India*. Our own data favour the conclusion that, in urban areas of the sample state, both home background and school factors are important influences on children's cognitive achievement. This conclusion is corroborated in Govinda and Varghese's (GV *op. cit.*) study, which shows that on average school and teacher influences account for only about 36% of total explained variation in pupil achievement. GV's results are intermediate between ours and H&L's and this may reflect the fact that they had better home background variables than H&L but not so rich as ours.

IV Conclusions

This paper attempted to identify the school, teacher, and peergroup factors that affect pupil achievement most significantly (holding pupil background constant), and examined the extent to which institutional influences dominate the home-background influences on student achievement.

We found that the most important institutional variables affecting student achievement in our sample are school facilities and materials, length of instruction per week, school management-type, and teachers' cognitive skills. This suggests that much of the educational data, discussion, and expenditure in India has been on measures of school quality that, according to our survey, are dubious indicators, such as class size (pupil-teacher ratios), teachers' training, experience, and possibly, teachers' post-graduate education and pay. The results of section III cast doubt on Heyneman and Loxley's (1982) dramatic conclusion that in India school factors are by far the most predominant influence on student achievement and that home factors count for little. Our own data favoured the conclusion that both home background and school factors are important influences on children's cognitive achievement.

Although additional research, with nationwide data on India, is warranted in order to be confident about the generalisability of the conclusions reached here, our results suggest that it would enhance school efficiency to spend monies in upgrading school facilities and materials, providing longer school days, better management practices, and more skilled teachers, but that investing in smaller pupil-teacher ratios (in urban areas where there is no multi -grade teaching), and investing in teacher experience, training, post-graduate education, and higher across-the-board teacher salaries may not be educationally sound expenditures in a resource scarce country such as India. Moreover, teacher selection and remuneration could place greater emphasis on the quality of education (*i.e.* cognitive skills) of teachers rather than on the years of schooling, training, and experience of teachers since these inputs are not significant in explaining variations in children's academic achievement.

Table 1 Definitions, means and standard deviations of variables

Name	Description	Mean	S.D.
ACHIEVE	Student's total achievement score, that is total of *SMATH* and *SREAD*	24.97	11.78
SMATH	Student's score on numeracy (maths) test	12.02	6.70
SREAD	Student's score on the literacy (reading) test	12.95	6.10
SRAVEN	Score on the ability test - Raven's Progressive Matrices test	30.53	11.23
CHAGE	Child's age in months	164.07	13.29
CEDASP	Child's educational aspirations; index from 1 to 6 of the highest education level to which child aspires, eg, 1=upto class 8, 4=first degree, etc.	4.56	1.34
TAKESTU	Student takes private home tuition yes=1, no=0	0.33	0.47
HSTUDY	Number of hours of home study per week	21.61	10.64
BOOKHOM2	Greater than 50 books at home? yes=1, no=0	0.26	0.44
BOOKHOM3	Greater than 100 books at home? yes=1, no=0	0.29	0.46
TRTIME	Travel time to school each way, in minutes	17.60	11.82
VACWRK	Child works during vacations and/or out of school hours? yes=1, no=0	0.14	0.35
NUMSIB	Number of siblings	3.99	1.71
MALE	male=1, female=0	0.53	0.50
WEALTH	Index of monetary value of assets in the household*, divided by 10	2.42	2.11
WEALTHSQ	Square of *WEALTH*	10.33	16.67
LOWCASTE	Belongs to the low caste? yes=1, no=0	0.13	0.34
MUSLIM	Religion Muslim? yes=1, no=0	0.22	0.41
MEDYRS	Mother's education in years, divided by 10	0.87	0.50
MEDYRSQ	Square of *MEDYRS*	1.00	0.79
PARHELP	Parents help with studies at home? yes=1, no=0	0.583	0.493
PEERFEM	Percentage of female students in class	46.416	43.156
GIRLSC	Single-sex girls' school? yes=1, no=0	0.357	0.479
VARAVEN	Variance of Raven's score of class pupils	83.358	25.423
ATEDUYRS	Weighted average of teachers' education in years	15.052	0.656
ATOTEXP	Weighted average of teacher experience in years	14.505	5.312
ADIVISIO	Weighted average of teachers' average division**	1.869	0.246
ATRAINYR	Weighted average. of teachers' training in years	1.173	0.328
AVSALARY	Average staff salaries in rupees per month	1790.400	686.820
CLNUM	Number of pupils in sample class	42.882	13.900
RESOURCE	Index of physical facilities & teaching aids***	8.901	3.878
NMINACAD	Minutes of academic instruction per week	1278.500	276.920

Notes: The weighting of teacher variables is by number of minutes per week the different teachers taught the sample class. For 0/1 variables, the mean represents the proportion of ones in the sample.

* The variable *WEALTH* was constructed by assigning the following values to owned assets: Car=50, scooter=15, video=15, fridge=6, telephone=5, TV=3, tape recorder and gas cooker=2 each and radio, bed(s), bicycle, and clock=1 each. Many children may not have known their parents' income but all knew the answer to the factual question on which of these assets their family owned.

** For each sample teacher, we constructed an index of the average grade she obtained in various board/degree exams, by assigning a value of 3 to first division, 2 to second division and 1 to third division. Thus, for example, if an individual teacher obtained first division in high school and second divisions in both intermediate (A-level equivalent) and in undergraduate degree, the average value of division for her will be 2.33. *ADIVISIO* is the weighted average of *DIVISION* value of all teachers who taught the sample class.

*** The resource index was constructed by giving a value of 1 for each of seventeen facilities such as availability of desks and chairs, blackboards, chalk, charts, playground, toilet, drinking water, musical instruments and educational-technology equipment such as slide projector, computer, and video.

Table 2 Achievement production functions, by subject

Variable	Maths		Reading		Achievement	
	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
Constant	-2.698	-0.58	-8.465	-1.84	-11.163	-1.48
SRAVEN	0.145	9.57	0.110	7.29	0.256	10.34
CHAGE	-0.023	-1.95	-0.131	-2.64	-0.053	-2.81
MALE	3.230	5.85	1.024	1.86	4.254	4.73
CEDASP	0.222	1.79	0.096	0.78	0.318	1.58
HSTUDY	0.054	3.67	0.027	1.85	0.080	3.38
TRTIME	0.008	0.60	0.018	1.46	0.026	1.26
VACWRK	-0.756	-1.82	-0.428	-1.04	-1.184	-1.75
TAKESTU	-0.413	-1.30	-0.480	-1.52	-0.892	-1.73
NUMSIB	-0.209	-2.14	-0.250	-2.58	-0.459	-2.89
PARHELP	-0.203	-0.67	-0.563	-1.86	-0.766	-1.54
MEDYRS	-2.642	-2.76	0.208	0.22	-2.434	-1.56
MEDYRSQ	1.718	2.82	0.163	0.27	1.881	1.90
WEALTH	0.774	2.74	0.787	2.80	1.561	3.40
WEALTHSQ	-0.059	-1.88	-0.065	-2.06	-0.124	-2.42
BOOKHOM2	-0.007	-0.02	0.198	0.57	0.191	0.34
BOOKHOM3	0.554	1.51	0.497	1.36	1.051	1.76
LOWCASTE	-1.234	-2.71	-1.118	-2.46	-2.352	-3.17
MUSLIM	-0.442	-1.15	0.179	0.47	-0.263	-0.42
PEERFEM	0.065	5.07	0.004	0.34	0.069	3.32
GIRLSC	-5.066	-4.66	-0.028	-0.03	-5.094	-2.88
VARAVEN	-0.010	-1.29	-0.024	-3.04	-0.034	-2.65
ATEDUYRS	-0.148	-0.57	0.823	3.18	0.675	1.60
ATOTEXP	-0.055	-1.35	0.019	0.47	-0.036	-0.54
ADIVISIO	2.997	3.81	1.554	1.98	4.551	3.56
ATRAINYR	0.529	0.82	0.070	0.11	0.599	0.57
AVSALARY	0.001	1.61	-0.000	-1.06	0.000	0.34
CLNUM	-0.022	-1.61	0.043	3.19	0.021	0.96
RESOURCE	0.280	4.69	0.372	6.25	0.652	6.71
NMINACAD	0.004	4.30	0.002	2.52	0.006	4.24
$\bar{R}^2$	0.6211		0.5463		0.6749	
N	902		902		902	

Table 3 Institutional determinants of achievement in other studies on India

Variable	Skill area	Direction of effect	Study
Class size	Reading and science	0	H&L
Instructional materials	Reading and science	+	C&K
Teachers' postsecondary schooling	Reading and science	+	C&K
Assignment of homework	Reading and science	0	C&K
Library available and used	Science	+	Thorndike
Laboratory available and used	Science	+	H&L
Teacher training	Science	+	H&L
Teachers' experience	Science	+	H&L
Length of instructional time	Science	+	H&L
Teachers' time in class preparation	Science	+	H&L

Source: Compiled from Fuller (1986).
Note: H&L refers to Heyneman and Loxley and C&K refers to Comber and Keeves.

Table 4 Home background and school influences on achievement

Study	Skill area (dependent variable)	Variance explained by home background variables (%) (a)	Variance explained by school variables (%) (b)	Total variance explained (%) (c)	Contribution of school variables to explained variance (%) (b/c)
Present study	Reading	47.8	6.8	54.6	12.5
	Maths	52.3	9.8	62.1	15.8
	Achievement	59.0	8.5	67.5	12.6
Heyneman & Loxley	Science	3.0	27.0	30.0	90.0

Source: Table 2 and Table 5 here; Heyneman and Loxley (1983, Table 2, p1174).

Table 5 Pupil and household determinants of achievement

Variable	Maths		Reading		Achievement	
	Coefficient	**t-value**	**Coefficient**	**t-value**	**Coefficient**	**t-value**
Constant	6.808	2.79	8.098	3.48	14.906	3.74
SRAVEN	0.201	12.46	0.161	10.48	0.362	13.77
CHAGE	-0.035	-2.75	-0.026	-2.20	-0.061	-2.97
MALE	2.559	7.82	0.884	2.84	3.443	6.46
CEDASP	0.389	2.88	0.325	2.53	0.714	3.24
HSTUDY	0.060	3.87	0.041	2.78	0.101	4.00
TRTIME	0,020	1.50	0.033	2.59	0.054	2.44
VACWRK	-0.800	-1.73	-0.524	-1.19	-1.324	-1.76
TAKETU	-1.061	-3.10	-0.841	-2.58	-1.902	-3.42
NUMSIB	-0.386	-3.60	-0.412	-4.03	-0.798	-4.56
PARHELP	-0.539	-1.61	-0.738	-2.32	-1.277	-2.34
MEDYRS	-2.653	-2.52	-0.060	-0.06	-2.713	-1.58
MEDYRSQ	1.651	2.48	0.575	0.91	2.226	2.06
WEALTH	1.672	5.51	1.571	5.44	3.242	6.56
WEALTHSQ	-0.105	-3.02	-0.110	-3.33	-0.215	-3.80
BOOKHM2	0.210	0.54	0.234	0.63	0.444	0.70
BOOKHM3	0.901	2.25	0.849	2.22	1.751	2.68
LOWCASTE	-1.094	-2.17	-1.218	-2.54	-2.312	-2.82
MUSLIM	-0.776	-1.85	-0.244	-0.61	-1.021	-1.49
$\bar{R}^2$	0.5227		0.4781		0.5897	
N	902		902		902	

Table 6 Institutional determinants of achievement

Variable	Maths		Reading		Achievement	
	Coefficient	**t-value**	**Coefficient**	**t-value**	**Coefficient**	**t-value**
Constant	-14.028	-3.24	-21.091	-5.12	-35.119	-4.88
PEERFEM	0.043	3.50	0.011	0.91	0.054	2.63
GIRLSC	-5.593	-4.71	-1.092	-0.97	-6.685	-3.39
VARAVEN	-0.030	-3.68	-0.039	-5.02	-0.069	-5.09
ADIVISIO	5.032	5.97	3.007	3.75	8.040	5.74
ATEDUYRS	0.488	1.72	1.329	4.93	1.817	3.86
ATOTEXP	-0.027	-0.59	0.044	1.01	0.017	0.23
ATRAINYR	0.548	0.79	0.012	0.02	0.559	0.49
AVSALARY	-0.000	-0.97	-0.001	-2.80	-0.001	-2.19
CLNUM	0.018	1.29	0.075	5.54	0.094	3.95
RESOURCE	0.524	8.69	0.592	10.35	1.115	11.16
NMINACAD	0.005	5.98	0.003	3.75	0.008	5.75
$\bar{R}^2$	0.5107		0.4678		0.5635	
N	902		902		902	

Table 7 Correlation between home and school characteristics

Variables	*ATEDUYRS*	*ADIVISIO*	*RESOURCE*	*NMINACAD*
WEALTH	0.26	0.51	0.59	0.38
MEDYRS	0.31	0.40	0.48	0.27
PEDYRS	0.34	0.41	0.53	0.33
LOWCASTE	-0.08	-0.13	-0.20	-0.07
NUMSIB	-0.27	-0.30	-0.34	-0.23

Appendix 1 Achievement production functions with school-type dummy

Variable	Maths		Reading		Achievement	
	Coefficient	**t-value**	**Coefficient**	**t-value**	**Coefficient**	**t-value**
Constant	-4.868	-1.06	-9.421	-2.04	-14.290	-1.91
SRAVEN	0.138	9.14	0.107	7.05	0.245	9.95
CHAGE	-0.029	-2.49	-0.033	-2.86	-0.062	-3.29
MALE	3.259	5.96	1.037	1.89	4.296	4.82
CEDASP	0.209	1.71	0.091	0.74	0.300	1.50
HSTUDY	0.052	3.62	0.026	1.81	0.078	3.33
TRTIME	0.010	0.84	0.019	1.57	0.030	1.48
VACWRK	-0.719	-1.75	-0.412	-1.00	-1.132	-1.69
TAKESTU	-0.407	-1.30	-0.477	-1.52	-0.884	-1.73
NUMSIB	-0.137	-1.40	-0.218	-2.22	-0.355	-2.23
PARHELP	-0.268	-0.89	-0.592	-1.95	-0.860	-1.75
MEDYRS	-2.268	-2.37	0.379	0.40	-1.875	-1.21
MEDYRSQ	1.401	2.31	0.023	0.04	1.424	1.44
WEALTH	0.689	2.46	0.750	2.67	1.439	3.15
WEALTHSQ	-0.060	-1.93	-0.065	-2.07	-0.125	-2.46
BOOKHM2	0.020	0.06	0.209	0.60	0.229	0.41
BOOKHM3	0.681	1.87	0.553	1.51	1.234	2.08
LOWCASTE	-1.015	-2.24	-1.022	-2.24	-2.037	-2.75
MUSLIM	-0.331	-0.87	0.228	0.60	-0.102	-0.17
PEERFEM	0.056	4.33	0.000	0.02	0.056	2.67
GIRLSC	-3.832	-3.45	0.516	0.46	-3.316	-1.83
VARAVEN	-0.007	-0.91	-0.022	-2.87	-0.029	-2.33
ATEDUYRS	0.086	0.33	0.926	3.51	1.012	2.36
ATOTEXP	-0.038	-0.93	0.027	0.66	-0.011	-0.17
ADIVISIO	1.289	1.48	0.801	0.92	2.090	1.48
ATRAINYR	0.528	0.83	0.069	0.11	0.597	0.58
AVSALARY	0.002	4.35	0.000	0.70	0.002	3.10
CLNUM	-0.013	-0.95	0.046	3.45	0.034	1.55
RESOURCE	0.166	2.58	0.322	4.97	0.488	4.64
NMINACAD	0.003	3.26	0.002	1.99	0.004	3.22
PUA school	4.052	4.43	1.786	1.94	5.838	3.91
$\bar{R}^2$	0.6291		0.5478		0.6802	
N	902		902		902	

Appendix 2 Achievement production functions: Estimates from a treatment effects model

Variable	Specification 1		Specification 2		Specification 3	
	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
Constant	-11.417	-1.27	-12.474	-1.43	-15.313	-1.85
SRAVEN	0.255	8.58	0.252	8.65	0.245	8.72
CHAGE	-0.054	-2.27	-0.057	-2.55	-0.064	-3.02
MALE	4.257	4.81	4.266	4.84	4.196	4.77
CEDASP	0.316	1.58	0.309	1.56	0.301	1.53
HSTUDY	0.080	3.41	0.079	3.40	0.078	3.35
TRTIME	0.026	1.23	0.028	1.35	0.032	1.58
VACWRK	-1.180	-1.76	-1.173	-1.76	-1.028	-1.57
TAKESTU	-0.892	-1.76	-0.894	-1.77	-0.948	-1.89
NUMSIB	-0.451	-1.95	-0.430	-1.87	-0.380	-1.71
PARHELP	-0.774	-1.51	-0.800	-1.58	-0.872	-1.76
MEDYRS	-2.388	-1.34	-2.184	-1.26		
MEDYRSQ	1.843	1.50	1.682	1.42		
WEALTH	1.551	3.14	1.508	3.11	1.454	3.11
WEALTHSQ	-0.124	-2.46	-0.124	-2.47	-0.126	-2.56
BOOKHOM2	0.194	0.34	0.211	0.38	0.249	0.45
BOOKHOM3	1.066	1.62	1.118	1.72	1.314	2.11
LOWCASTE	-2.326	-2.60	-2.160	-2.69	-1.951	-2.55
MUSLIM	-0.250	-0.37				
PEERFEM	0.068	2.27	0.064	2.21	0.049	1.93
GIRLSC	-4.950	-1.45	-4.376	-1.36	-2.174	-0.97
VARAVEN	-0.033	-2.33	-0.032	-2.27	-0.030	-2.14
ATEDUYRS	0.702	1.01	0.820	1.26	1.087	1.84
ATOTEXP	-0.034	-0.44	-0.025	-0.33	-0.005	-0.06
ADIVISIO	4.351	1.03	3.531	0.90	1.774	0.51
ATRAINYR	0.599	0.58	0.633	0.62	0.632	0.62
AVSALARY	0.000	0.10	0.001	0.31	0.003	0.94
CLNUM	0.022	0.73	0.027	0.96	0.035	1.32
RESOURCE	0.639	2.23	0.587	2.18	0.465	1.95
NMINACAD	0.005	2.25	0.005	2.20	0.004	1.97
Z	0.474	0.05	2.389	0.27	6.992	0.92
$\bar{R}^2$	0.6754		0.6785		0.6804	

Note: The dependent variable is *ACHIEVE*. Z is the instrument for *PUA* school. It is the probability of choosing a *PUA* school and is generated from the binary probit model of choice of a *PUA* school.

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[1] Studies which examine the association between student achievement and labour market productivity - as measured by earnings - are Boissiere, Knight, and Sabot 1985, Glewwe 1991, Moll 1992, *inter alia*.

[2] Heyneman and Loxley argued that the process of model specification in the original IEA studies (Comber and Keeves and Thorndike) was erroneous. These analyses had averaged the beta coefficients across countries and allowed variables to enter the final regressions only if the average coefficient was greater than 0.05. This severely constrained the influence of school and teacher quality because it eliminated from consideration those characteristics which had important effects in one country but not across an average of all countries.

[3] It is estimated that only 53% of the class 1 cohort of 1983 had reached grade 5 in 1987 (Colletta and Sutton 1989, p 3). Although much of this drop-out may be due to (measurable) economic reasons, some is also likely to be due to unmeasurable motivational/ability related reasons.

[4] It should be noted that when the whole array of non-pupil variables was added to the regression equation together, the parameter matrix was not of full rank - there was too much collinearity among the regressors. In any case, with only 30 school observations, the number of degrees of freedom available was small. Thus, we entered institutional variables in batches and retained/eliminated regressors on the basis of individual and joint tests. The coefficients on each of the peer, teacher and school variables finally retained are reasonably stable with respect to the addition/removal of other such variables.

[5] The sensitivity of the coefficients on these two variables to the inclusion of the school-type dummy is understandable given that both are well correlated with *PUA* school, *AVSALARY* being highly negatively correlated and *ADIVISIO* being positively (and less strongly) correlated.

[6] GOI (1985) recognises this problem. It states (p29) that "to meet ends of equity, it will have to be ensured that opportunity for studying science and mathematics would [*sic*] be available for girls as well as boys in all secondary schools up to class 10, so that all pupils would be able to exercise equal freedom of choice with regard to [the] professions they would like to pursue".

[7] Almost all the teachers in the sample had at least an undergraduate degree.

[8] Though self-selection into well-resourced schools on the basis of unobserved student characteristics may also account for part of the effect.

[9] This result should be qualified by saying that multi-grade teaching (prevalent in a high proportion of Indian rural primary schools) was not a problem in the schools in our urban sample. It is possible, even likely, that the multi-grade teaching of a large number of pupils by a single teacher has detrimental effects on pupil achievement.

[10] There are studies in Indian journals of educational psychology that also examine the determinants of pupil achievement in India but these generally use methods other than multivariate regression analysis such as correlation analysis and others (for example, see Verma and Gupta 1990, Veeraraghavan and Samal 1988, R. Srivastava (1985), and Jagannathan (1986). For a review of such studies, see H. Srivastava (1985) of the National Council of Educational Research and Training.

[11] International Association for the Evaluation of Educational Achievement.

[12] In the light of our findings, the 'Operation Blackboard' initiative of the Government of India - which seeks to upgrade facilities and teaching materials in all elementary schools - should be an effective quality-enhancing project. However it has not been consistently implemented (see Dhingra 1991).

[13] Since Heyneman and Loxley's (1983) study is based on 29 countries, the separate achievement production functions fitted for each country have not been reported in their paper and their achievement regression for India cannot, therefore, be reproduced here.

[14] A regression of *HSTUDY* on home and school factors confirmed that indeed hours of home study per week is determined partly by the home educational environment and partly by school-type.

[15] The IEA data on India, on part of which H&L's study is based, was collected in 1971 from 2400 pupils in 155 Hindi-medium schools in 4 states. The IEA study collected data from students in three age-groups namely 10 year olds, 14 year olds and from those in final year of secondary school (H&L 1983, p1165). However, H&L only use data on 14 year olds and so it is likely that the number of schools with 14 year olds was less than 155. Nevertheless, it is likely to have been at least half, that is, approximately 75 or more schools.

[16] The school variables used in H&L's study were number of students in laboratory classes, time reading science text in class, percentage of teachers in school teaching science, use of textbooks in science class, teachers' hours preparing reading lessons and hours per week preparing science lessons, science and reading teachers' ages, hours per week marking papers in science, average hours of school per week, hours of science preparation outside school time, hours of homework per week in general science, years of teacher education and training in reading, bio logy, and physics, and other sciences, frequency of use of audio-visual materials in reading classes, budget for school maintenance, annual budget for books, time on biology lab work and on general lab work, and hours of instruction per week in language and in general science (H&L, 1983, p1186-87).