The Joint Role of School and Home Inputs in Children's Learning

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Abstract

We estimate a production function of learning in Vietnam, a country which is unique among Lower and Middle Income Countries in the exceptionally high learning levels which are achieved for its level of wealth. The rich longitudinal data we use allows us to model primary school children's skills as a function of both home and school inputs. Our results suggest that, for both math and language skills, home and school inputs are (if anything) substitutes. However, parents appear to react to higher classroom quality by investing more in their children, suggesting that they have biased beliefs about the interaction between school and home inputs in the production of learning.

1 Introduction

It is well established that development during childhood is critical for lifetime human capital accumulation. Large literature exist on the roles played by key actors in this process – parents and schools. However, to date the great majority of papers treat these in isolation – Child Development literature has focused on the parents while school Value Added literature on the schools. Clearly though children's learning and development outcomes are a product of the combination of these inputs which, furthermore, may be inter-dependent. An important next step in understanding how skills are formed and what drives formation of inequalities between children, is to bring these literature together.

This is what we do in this paper which studies the joint role played by parents and schools in the formation of skills of primary school-age children in Vietnam. Vietnam is an outlier among Lower-Middle Income countries with respect to the very high levels of learning achieved for its income level (Dang et al., 2021). Understanding how this is achieved is a policy and academically relevant question. In a companion paper we have presented findings which show that variation in teacher quality alone explains less variation in primary school pupil attainment than has been found in other contexts (Carneiro et al, 2022). This result suggests that differences in home inputs or the ways in which home inputs respond to school inputs may play an especially important role in this context. This motivates the aim of this paper to assess the combined role of home and school inputs.

We utilise a rich longitudinal data set from 140 primary schools and over 5,000 primary school pupils in Vietnam. We estimate separate skill production functions for combined measures of academic skills as well as separately for mathematics and verbal skills including measures of school and home inputs. Our primary measure of school inputs is the class value added estimate. An important distinguishing feature of this study is that we collect detailed information on both the school and the home settings. We conducted in-depth interviews with the parents of the children in our sample in order to capture key features of the home environment and parental material and time investment in the sampled child.

Having assessed the joint role of home and school inputs, we then focus on the relationship between the two. In particular, we examine whether and how parents respond to the quality of their child's teacher. This will depend on what they believe about the relationship between home and school inputs in the child skill production function. This is a critical question for at least two reasons. First, clearly whether parents believe home investments to be complements or substitutes to school investments will play a key role in determining the impact of any government investments in quality of schooling on pupil outcomes. Second if parents respond to changes in school inputs then not taking these responses into account in the estimation of the education production function (as is most commonly done in this literature) will lead to inconsistent estimates.

There are several identification challenges in this analysis. The first is potential sorting of students and teachers which would bias our estimates of class effects, as well as of the parental response to classroom quality. We sample two classes per cohort per school in order to be able to estimate classroom specific effects within a school-grade-year, thus addressing concerns about non-random selection of pupils into schools. In order to address concerns about sorting within a school across classes we are able to rely on teacher and principal reports on how children and teachers are assigned to classes. Finally, we check for as good as random assignment of pupils within school across classes using observable student characteristics. Even with robust measures of class quality we face the risk that omitted home inputs, unobserved shocks and child latent ability may bias our estimates of the production function parameters. We address these concerns by exploiting the panel aspect of our data in order to estimate value added production functions where these omitted inputs and latent ability are proxied by a lagged test score (as in Todd and Wolpin, 2007; Fiorini and Keane, 2014; Keane et al, 2022). Several recent studies find VA models are a reliable way to control for latent ability.[1]

Our preliminary findings provide evidence that both school and home inputs are important for development of school curriculum math and verbal skills in early primary school. The results suggest that, controlling for quality of school inputs, within the home environment, for this age-group, children's own time investment is most strongly associated with attainment, followed with a less precisely estimated overall positive association between academic skills and parental material investments. This association is significantly stronger and is statistically significant for higher ability children, however. We also find evidence of substitutability between home material inputs and school inputs in the production of math skills.

Analysis of parental behaviour however suggests that parents do not have correct beliefs about the skill production function. While they have correct beliefs about the quality of the school input they respond to improvements in school quality by increasing material investments at home suggesting that they believe school quality and home inputs to be complements.

This paper makes several contributions to the literature. We are only aware of one other recent study which combines school and home inputs in the estimation of the child skill production function, but does so for a different context (US) and younger (pre-school age) children (Agostinelli, Saharkhiz, and Wiswall, 2019). There is also only a handful of studies that study the question of parental response to school inputs. Findings in this literature are mixed. While Das et al., 2013 find that in the context of India and Zambia parental response to unanticipated increases in public education spending are consistent with a situation in which household believe public and household educational spending to be substitutes, using directly elicited parental beliefs data, Attanasio, Boneva, and Rauh, 2019 find the reverse to be the case in the UK. Using data on actual parental behavior also in the UK context,

[1] These studies rely on simulation (Guarino et al., 2015) or comparison of experimental and VA estimates (Angrist, Pathak, and Walters, 2013; Deming et al., 2014; Muralidharan and Sundararaman, 2013).

however, Greaves et al show that parents actually reduce time investment in children in response to school quality improvements (Rasul et al., 2021).

We study a new context - Vietnam – which is a particularly interesting case since, at least anecdotally, parents here are more vested in their children's education than parents in other contexts. We are also able to distinguish between quality of teachers in teaching different subjects, allowing for the possibility that parents perceptions about interactions between home and school investments are not the same across skills.

The remainder of the paper proceeds as follows: Section 2 provides some details about the study context. We discuss the data in Section 3 and present the empirical strategy in Section 4. Our main findings are set out in Section 5 and Section 6 concludes.

2 Education in Vietnam

Vietnam's primary and secondary education system is divided into primary school (grades 1-5, starting at age 6), lower secondary school (grades 6-9), and upper-secondary school (grades 10-12). Vietnam also has pre-primary education (for ages 3-5), secondary vocational training schools, and many different post-secondary institutions. In 2014, Vietnam had more than 15,000 primary schools, 10,000 lower-secondary schools, and 2,300 upper secondary schools.

Virtually all primary schools in Vietnam are state-managed and thus are public schools. In 2013, about half of primary schools were providing "full day" (6 hours) instruction; the other half received only "half day" (3.5 hours) instruction, with schools usually operating two shifts. An explicit goal of the government is to extend full-day schooling to poorer localities, but this has proceeded slowly. At first glance, Vietnamese children's time in school seems very low; it has one of the shortest school days, and one of the shortest school years, in the world. Yet in most areas of Vietnam – including rural areas – parents send their primary-age children to varying hours of "extra study" classes, though the time and resources devoted to this activity vary across provinces.

Administratively, the Ministry of Education and Training (MoET) in Hanoi retains formal authority over the entire education system. MoET works with other line ministries to determine investments in education, and plays the leading role in education planning and in determining the content of curriculum (London, 2011).

3 Data and Measurement

3.1 Study and Sample

The data used in this paper were collected from 140 primary schools that are approximately nationally representative of all of Vietnam's primary schools. To date, data have been collected for four school years, 2017-18, 2018-19, 2019-20, and 2020-2021. For each of the 140 schools, data were collected for two adjacent cohorts of students, those who started grade 2 in the 2017-18 school year (henceforth cohort 1), and those who started grade 2 in the 2018-19 school year (cohort 2). Data were collected from cohort 1 for the 2017-18, 2018-19 and 2019-20 school years, when they were in grades 2, 3 and 4, and data were collected from cohort 2 for the 2018-19, 2019-20 and 2020-21 school years, when they were in grades 2, 3 and 4. Table 1 shows when the data were collected from the two cohorts.

Table 1: **Dates of Data Collection for Two Cohorts of Students**

Date	Nov 2017	April 2018	Nov 2018	April 2019	April 2020	April 2021
Cohort 1	Grade 2	Grade 2		Grade 3	Grade 4	
Cohort 2			Grade 2	Grade 2	Grade 3	Grade 4

For both cohorts, more than 5,000 students were tested in Mathematics and Vietnamese in their classroom when they were in grade 2, 3 and 4. The data was collected from a random sample of 20 students per class and each test lasted an hour. Table 2 provides some basic information on both cohorts when they were in grade 2. As can be seen, the two adjacent cohorts are quite similar; none of the differences is significant at the 5% level, although the differences for birth order and gender are significant at the 10% level.

We collected more detailed data on a random sub-sample of slightly more than 1,600 students in each cohort, including conducting in-depth interviews with these students, as well as their primary caregivers and conducting more in-depth assessments of the students' skills. This is the sub-sample that we focus on in this paper.

The pupils are spread across 140 schools and, in most cases, 2 classes per school. In each class we administered a detailed teacher questionnaire and filmed how the teacher conducts lessons. A feature that we exploit in this paper is that in 62 of the schools the teachers did not move with the class, which means that we observed the same teachers teaching classes from two neighbouring cohorts of children. Therefore, our final analysis sample consists of children who were in grade 2 either in 2017/18 or 2018/19, for whom we conducted mathematics and Vietnamese assessments at the beginning and

Table 2: Sample Statistics (Grade 2)

	Cohort 1		Cohort 2	
	mean	sd	mean	sd
Age in years	7.416	0.558	7.386	0.564
Proportion Ethnic minority	0.232	0.422	0.249	0.432
Proportion Male	0.539	0.499	0.506	0.500
Birth order	1.985	1.130	1.898	1.116
Mother's highest grade	8.554	3.361	8.577	3.470
Father's highest grade	8.688	3.266	8.496	3.247
Father's age	36.977	6.508	36.812	5.955
Mother's age	34.007	5.859	34.031	5.557
Students tested (Math,Vietnamese)	5070		5209	
Students interviewed (including Ncog)	1654		1673	
Schools	140		140	
Classrooms	276		279	

end of grade 2, who were interviewed along with their parents at the end of grade 2 and who were in schools where teachers did not move with the class. This gives us a sample of 1450 children, spread across 60 schools and 120 classes (2 per school).

3.2 Key Measures

3.2.1 Academic Skill Assessments

The initial Mathematics and Vietnamese tests given at the beginning of grade 2 both had 25 items (questions). Tests administered at the end of grade 2 had 30 items. Common (linking) items were included in order to put students' performance on these tests on a common scale, using item response theory (IRT).

For both the Mathematics and Vietnamese tests, items were developed for each grade by the Vietnam Institute of Educational Sciences. All tests administered during the RISE project assess domains relevant to the Vietnamese curriculum. The Maths test assesses three skills: arithmetic, measurement and quantities and geometry and Vietnamese test assesses four language skills: vocabulary, rhetoric, grammar and reading comprehension. They both assess the following cognitive domains - knowledge, understanding and application. We conducted two pilot tests, the first was done in May of 2017, before the first round of data collection, and the second was in January of 2019, before collecting data from grade 4. For both pilot tests, about 300 students and their teachers participated for each grade. The best performing test items (questions) were selected by using IRT diagnostic analysis. Final scores on (the final versions of) each test were constructed using a 2-parameter IRT model, and items with poor performance were excluded from the dataset.

To compare students across the two cohorts, all test results were combined into a single data set (separately for math and Vietnamese) and IRT analysis was used to construct latent measures of mathematics and Vietnamese ability for each student that are comparable across grades and across the two cohorts. For ease of interpretation, these math and Vietnamese latent scores were normalized to have a standard deviation of one and mean of zero within each grade.

3.2.2 School Inputs

In line with the education literature, we capture classroom quality as latent fixed effects, leveraging the fact that we have multiple pupils per class and beginning and end of grade test-scores. We estimate the following regression equation:

$$Y^k_{icst} = \alpha^k_{cs} + \beta Y^k_{icst-1} + \epsilon^k_{icst} \tag{3.1}$$

where Y^k_{icst} is end-of-school-year score of student i in classroom c in school s at time t on a test for subject k (mathematics, Vietnamese), α_{cs} are classroom indicators, Y^k_{icst-1} is beginning-of-school-year score on subject k and ϵ^k_{icst} is an i.i.d. error term. The classroom fixed effects (α_{cs}) are estimates of classroom value added under the assumption that, conditional on controls (primarily the test score at the beginning of the school year or at the end of the previous grade) students are randomly assigned to classrooms. It is not plausible that students are randomly assigned to schools, even conditional on past learning, but it is generally accepted that the assumption of conditional random assignment within school is reasonable (e.g., Chetty, Friedman, and Rockoff, 2014). Therefore, since we have two classrooms per school, as in most papers in this literature, we redefine each classroom effect relative to the school average to address the issue of sorting of teachers and/or students into schools. The downside of this approach is that it eliminates any cross-school variation in school quality.

The demeaned classroom effect, used in the analysis, denoted by λ^k_{cs}, is:

$$\lambda^k_{cs} = \alpha^k_{cs} - \frac{\sum_{c=1}^{C_s} N_{cs}\alpha^k_{cs}}{\sum_{c=1}^{C_s} N_{cs}} \tag{3.2}$$

where C_s is the number of classrooms in a school and N_{cs} is the number of students in the classroom c in school s (in our analysis C_s always equals 2). Since we utilise this measure in individual level regressions with pupil test score as the dependent variable (see next Section) we construct an individual level measure of the class effect which excludes the individual's test scores. Furthermore to improve efficiency we utilise data from both cohorts and construct a class value added measure for the analysis which is the average of the class value added estimates for the two cohorts.

3.2.3 Home Inputs

We collected a rich set of measures of the child's home environment and parental investment through the caregiver interview. These include the time the child spends studying at home, how much help the child gets with home study from adult members of the household, availability of key study materials to the child at home - access to study space and key study materials at home including notebook, textbook, exercise kit, pencils etc. We also have measures of financial investments in child learning captured through educational expenditure on the child in the last 12 months on a range of inputs including study materials, travel to and from school, exam fees, extra-curricular and educational activities.

We combine these measures and construct three measures of home inputs: parental material investment, parental time investment and child time investment. Child's time investment captures the amount of time that the child spends on homework on a school day of a typical school week and is standardized to have a mean zero and standard deviation of one. Parental time investment combines time spent by the parent on several activities with the child (e.g. reading, telling stories, singing, doing arts, playing sports, studying, talking, watching tv)and the frequency with which the child receives help with homework. We combine the activities into a factor and standardize it to have mean zero standard deviation one. Similarly we standardize the frequency with which the child receives help with homework. We then take the average of the two and re-standardize in order to create a single parental time investment measure. The material inputs measure combines standardized total educational expenditure and standardized factor of educational materials available to the child at home. The combined measure is re-standardized to have mean zero and standard deviation one.

4 Empirical Strategy

We start by estimating a child skill production function which includes school and home inputs. We capture school inputs through the demeaned classroom fixed effect and home inputs through the three measures of inputs described above. In order to address concerns about omitted inputs we control for the child's lagged skills (using assessments administered at the beginning of grade 2) and control for some fixed characteristics of the child's home environment. Our empirical specification is as follows:

$$Y_{icst} = \alpha_0 + h_{icst}^{\intercal}\alpha_1 + \alpha_2 c_{cst} + x_{icst}^{\intercal}\alpha_3 + \alpha_4 Y_{ics,t-1} + \nu_{icst} \tag{4.1}$$

Where Y_{icst} is the end of year test score (averaging scores in mathematics and Vietnamese) of child i from class c in school s at time t (end of Grade 2); $Y_{ics,t-1}$ is the child's average score on the mathematics and Vietnamese assessments at the beginning of the school year; $h_{icst}^{\intercal}$ is a vector of home inputs (described above); c_{cst} is the class fixed effect capturing school inputs; $x_{icst}^{\intercal}$ are additional timeinvariant controls for the home environment of the child including maternal education and household wealth.

We then look at parental response to school quality. To do this we estimate the following model:

$$H_{icst} = \beta_0 + \beta_1 c_{cst} + x_{icst}^{\intercal}\beta_2 + \upsilon_{icst} \tag{4.2}$$

Looking at the association between school quality and each of our measures of parental investment individually.

5 Preliminary Results

5.1 Test Score Production Function

We start by presenting estimates of the academic skill production function in Table 3. The outcome variable is the average of a child's test scores on Mathematics and Vietnamese at the end of Grade 2. Measures of home inputs include material investment by the parent, time investment by the child and time investment by the parents (see Section 3 for description of how these are constructed). We use the average of Mathematics and Vietnamese class fixed effect estimates to capture school inputs. All regressions control for child baseline score (average of Mathematics and Vietnamese) and cohort fixed effects; regressions presented in Columns (2)-(5) also include dummies for maternal education and household wealth index.

Table 3: Production function (math and viet combined)

	(1)	(2)	(3)	(4)	(5)
Leave-one-out Combined VA	0.095***	0.083***		0.079***	0.079***
	(0.014)	(0.014)		(0.014)	(0.014)
Material investment			0.032**	0.022	0.023
			(0.015)	(0.015)	(0.015)
Time investment - child			0.039***	0.036***	0.033**
			(0.014)	(0.014)	(0.013)
Time investment - parents			-0.011	-0.014	
			(0.015)	(0.015)	
Baseline score	0.693***	0.655***	0.671***	0.648***	0.650***
	(0.018)	(0.020)	(0.019)	(0.020)	(0.020)
Observations	1389	1389	1400	1389	1389
R^2	0.573	0.580	0.587	0.583	0.582

Notes: All regressions control for dummies for maternal education, household wealth, and cohort fixed effects, except column 1 that only includes cohort fixed effects. *** p<0.01, ** p<0.05, * p<0.1.

In all specifications school inputs are highly statistically significant. A one standard deviation in class value added leads to just under a tenth of a standard deviation improvement in a child's math score at the end of Grade 2. The association between home inputs and academic skills is moderated by school inputs. Column (3), which excludes school inputs, shows that there is a positive and significant association between academic skills and parental material investments as well as child time investment. Once we add controls for school inputs, however, the coefficient on material investment goes down moderately and become statistically insignificant (Columns (4)-(5)). Parental time investment remains insignificant throughout and Col(5) shows that leaving it out has no effect on coefficients of the other variables.

Splitting the results by subject we see that both home and school inputs play a bigger role in explaining variation in Mathematics scores (Table 4 than Vietnamese Table 5).

Table 4: Math Production function

	(1)	(2)	(3)	(4)
Leave-one-out Class VA math	0.136***	0.125***		0.121***
	(0.014)	(0.014)		(0.014)
Material investment			0.046**	0.020
			(0.018)	(0.015)
Time investment - child			0.037**	0.037***
			(0.017)	(0.014)
Time investment - parents			-0.001	-0.007
			(0.019)	(0.015)
Baseline score	0.650***	0.616***	0.649***	0.610***
	(0.020)	(0.021)	(0.024)	(0.021)
Observations	1354	1354	1400	1354
R^2	0.546	0.553	0.474	0.556

Notes: All regressions control for dummies for maternal education, household wealth, and cohort fixed effects, except column 1 that only includes cohort fixed effects. *** p<0.01, ** p<0.05, * p<0.1.

We then investigate the production function in more detail by assessing whether returns to inputs vary by child ability as well as by levels of other inputs. Table 6 shows estimates for combined academic skills measure of outcomes (Mathematics and Vietnamese), followed by Tables 7 and 8 showing results separately for Mathematics and Vietnamese respectively. In all three tables Column 1 does not include interaction terms; Column 2 includes interaction only for our school input measure - "class VA"; Column 3 includes interaction only for "material investment"; Column 4 includes interaction only for "time investment"; Column 5 includes interactions only for "child baseline score"; Column 6 includes all interactions.

Table 5: Vietnamese Production function

	(1)	(2)	(3)	(4)
Leave-one-out Class VA Viet	0.065***	0.060***		0.060***
	(0.015)	(0.015)		(0.015)
Material investment			0.018	0.005
			(0.019)	(0.016)
Time investment - child			0.041**	0.022
			(0.018)	(0.015)
Time investment - parents			-0.021	-0.013
			(0.019)	(0.016)
Baseline score	0.723***	0.682***	0.694***	0.678***
	(0.022)	(0.024)	(0.025)	(0.024)
Observations	1345	1345	1400	1345
R^2	0.494	0.501	0.478	0.502

Notes: All regressions control for dummies for maternal education, household wealth, and cohort fixed effects, except column 1 that only includes cohort fixed effects. *** p<0.01, ** p<0.05, * p<0.1.

The result that emerges most strongly in Table 6 is that there is a significant positive interaction between baseline child academic score and parental material investments, suggesting that home material investments are more productive for more academically able children. Breaking these results down by subject in Tables 7 and 8 we see that this finding holds for both Mathematics and Vietnamese. For Vietnamese we also see evidence that unlike home material inputs, school inputs are more productive for less able children.

While there are no strong significant interactions between inputs for Vietnamese (and overall), we do find evidence consistent with substitutability between school and home material inputs in production of Math skills.

Table 6: Production function with interactions (math and viet combined)

	(1)	(2)	(3)	(4)	(5)	(6)
Leave-one-out Combined VA	0.079***	0.083***	0.078***	0.082***	0.084***	0.085***
	(0.014)	(0.015)	(0.014)	(0.014)	(0.014)	(0.014)
Material investment	0.023	0.024	0.022	0.023	0.020	0.021
	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)
Time investment - child	0.033**	0.032**	0.033**	0.023*	0.028**	0.024*
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Baseline score	0.650***	0.650***	0.651***	0.648***	0.651***	0.649***
	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
Class × Material		-0.005	-0.021			-0.019
		(0.013)	(0.014)			(0.014)
Class × Time		-0.012		-0.026*		-0.024
		(0.014)		(0.015)		(0.015)
Class × BL score		-0.013			-0.026*	-0.020
		(0.015)			(0.015)	(0.015)
Material × Time			-0.017	-0.017		-0.022
			(0.014)	(0.014)		(0.014)
Material × BL score			0.051***		0.039**	0.054***
			(0.018)		(0.017)	(0.018)
Time × BL score				0.058***	0.042**	0.058***
				(0.018)	(0.017)	(0.018)
Observations	1389	1389	1389	1389	1389	1389
R^2	0.582	0.583	0.585	0.586	0.587	0.589

Notes: All regressions control for dummies for maternal education, household wealth, and cohort fixed effects. *** p<0.01, ** p<0.05, * p<0.1.

Table 7: Math production function with interactions

	(1)	(2)	(3)	(4)	(5)	(6)
Leave-one-out Class VA math	0.121***	0.118***	0.118***	0.121***	0.123***	0.120***
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
Material investment	0.020	0.023	0.023	0.022	0.020	0.023
	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)
Time investment - child	0.036***	0.036***	0.036***	0.030**	0.030**	0.030**
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Baseline score	0.611***	0.609***	0.608***	0.609***	0.609***	0.606***
	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)
Class × Material		-0.033**	-0.046***			-0.046***
		(0.014)	(0.015)			(0.015)
Class × Time		0.016		-0.004		-0.003
		(0.014)		(0.015)		(0.015)
Class × BL score		0.002			-0.013	-0.006
		(0.018)			(0.018)	(0.018)
Material × Time			0.019	0.004		0.010
			(0.014)	(0.014)		(0.014)
Material × BL score			0.036**		0.019	0.036*
			(0.018)		(0.017)	(0.018)
Time × BL score				0.062***	0.062***	0.063***
				(0.018)	(0.017)	(0.018)
Observations	1354	1354	1354	1354	1354	1354
R^2	0.556	0.558	0.560	0.560	0.561	0.564

Notes: All regressions control for dummies for maternal education, household wealth, and cohort fixed effects. *** p<0.01, ** p<0.05, * p<0.1.

Table 8: Vietnamese production function with interactions

	(1)	(2)	(3)	(4)	(5)	(6)
Leave-one-out Class VA Viet	0.055***	0.068***	0.054***	0.057***	0.067***	0.068***
	(0.016)	(0.017)	(0.016)	(0.017)	(0.017)	(0.017)
Material investment	0.045**	0.044**	0.047***	0.047***	0.042**	0.046***
	(0.017)	(0.018)	(0.018)	(0.018)	(0.017)	(0.018)
Time investment - child	0.035**	0.035**	0.037**	0.029*	0.033**	0.031*
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
Baseline score	0.714***	0.717***	0.716***	0.714***	0.720***	0.720***
	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)
Class × Material		-0.001	-0.018			-0.014
		(0.016)	(0.016)			(0.017)
Class × Time		-0.019		-0.031*		-0.026
		(0.017)		(0.018)		(0.018)
Class × BL score		-0.048**			-0.057***	-0.052**
		(0.020)			(0.020)	(0.020)
Material × Time			0.003	0.010		0.005
			(0.017)	(0.017)		(0.017)
Material × BL score			0.044*		0.046**	0.051**
			(0.023)		(0.022)	(0.023)
Time × BL score				0.036	0.025	0.032
				(0.024)	(0.023)	(0.024)
Observations	1345	1345	1345	1345	1345	1345
R^2	0.493	0.496	0.495	0.495	0.498	0.499

Notes: All regressions control for dummies for maternal education, household wealth, and cohort fixed effects. *** p<0.01, ** p<0.05, * p<0.1.

5.2 Parental response to teacher quality

Having demonstrated the importance of both home and school inputs in the production of academic skills, and provided suggestive evidence of heterogeneity in returns to investments by child ability as well as interactions between inputs, we now ask whether parental and child investment in skill accumulation at home is responsive to school quality and whether these responses are optimal given what we have learned about the production function.

5.2.1 Parental perceptions of teacher quality

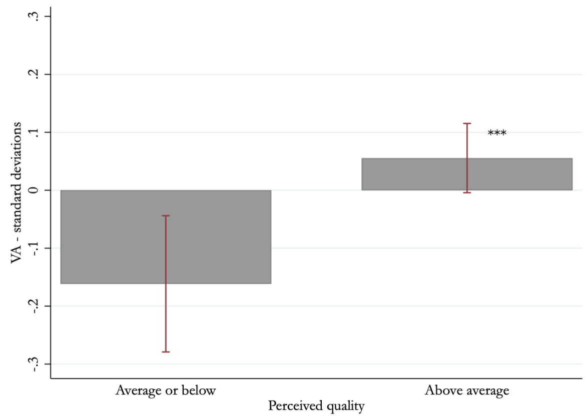
The first step in this analysis is to shed some light on parental perceptions. If parents respond to school quality, it is to what they perceive it to be. In order to interpret their responses we need to first understand how parents' perceptions map to objective measures of quality.

In order to do this we utilise information collected from parents on how good they think their child's teacher is to capture parental perceptions of teacher quality. We use our class value added estimate to capture teachers' actual quality.

We look at the relationship between perceived and actual quality in two ways. First we use the individual parental responses and look at the correlation between parents' rating of the teachers and class value added estimates for that teacher[2]. Figure 1 shows mean value added of classes of teachers who parents rated as average, below average or above average. It clearly shows that parental assessment of teachers aligns with their actual quality: the mean value added of classes taught by teachers rated above average by parents was significantly higher than that of classes taught by teachers rated by parents as average or below average. Figures 2 and 3 further show that this remains the case for both subject specific class value added measures, that is, teachers rated by parents as above average have a higher class value added in mathematics and Vietnamese than those rated by parents as average or below.

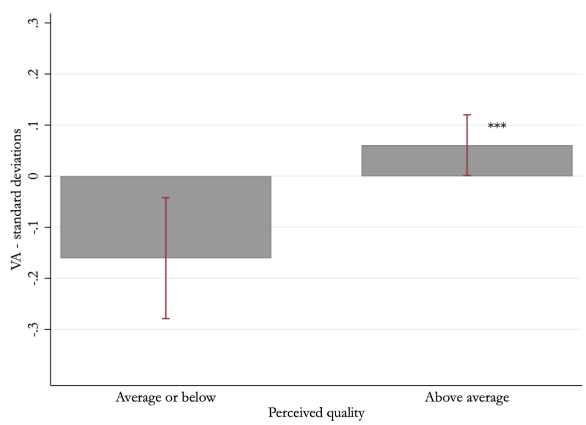
[2]The class value added estimate is for the cohort that the given parent's child was in rather than for the two cohorts

Figure 1: Perceived quality and VA - Combined



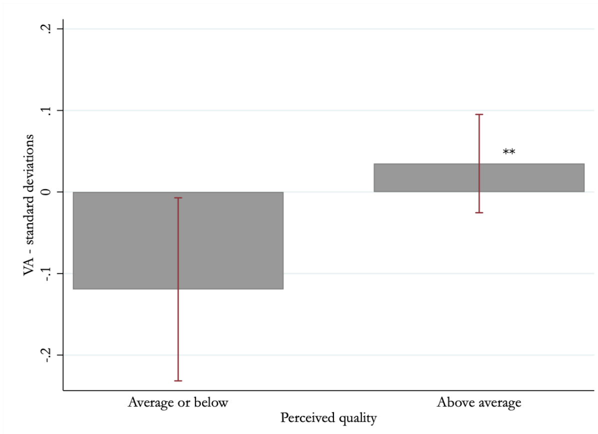
Notes: The Figure plots the means and confidence intervals of class value added by parent's rating. *** p<0.01, ** p<0.05, * p<0.1.

Figure 2: Perceived quality and VA - Math



Notes: The Figure plots the means and confidence intervals of class value added by parent's rating. *** p<0.01, ** p<0.05, * p<0.1.

Figure 3: Perceived quality and VA - Vietnamese



Notes: The Figure plots the means and confidence intervals of class value added by parent's rating. *** p<0.01, ** p<0.05, * p<0.1.

Another way to look at the relationship between true and perceived quality is to compute the average parent rating for each teacher (by averaging across parents of children in the same class) and then regress this average rating on the value added measure. The level of observation is the teacher $\times$ cohort (2 observations per teacher). The results in Table 9 show that a higher value added predicts (i) higher average ratings from the parents, and (ii) lower variability in the ratings.

Table 9: Teacher ratings and VA

	Mean Rating			S.D.Rating		
	(1)	(2)	(3)	(4)	(5)	(6)
Combined VA (average)	0.042**			-0.020		
	(0.019)			(0.016)		
VA math		0.036*			-0.027*	
		(0.019)			(0.016)	
VA Vietnamese			0.037*			-0.007
			(0.019)			(0.016)
Observations	240	240	240	239	239	239
R^2	0.020	0.015	0.015	0.007	0.013	0.001

Notes: *** p<0.01, ** p<0.05, * p<0.1.

5.2.2 Parental response to teacher quality

Having established that on average parents have accurate perceptions about teacher quality, we now look at whether and how they respond to variation in teacher quality. To do this we estimate the model in Equation 4.2, regressing measures of home investments (parental material investment and child time investment) on our measure of school quality - class value added - controlling for maternal education, household wealth and cohort fixed effects.

The results in Table 10 suggest that parents and children do indeed adjust their investment behaviour to the quality of schooling. The positive coefficients on the combined and subject specific measures of class value added in Columns 1-3 are consistent with parents increasing their material investments in response to an increase in school quality. Estimates of the model in which we use a combined measure of class quality suggests that a one standard deviation increase in class quality is associated with a 12% sd increase in parental material investment. We see a more mixed patterns in the child homework time response - children appear to respond to an improvement in the quality of mathematics teaching by increasing the time that they spend on homework. However, there is no such response to improvements in quality of Vietnamese teaching and, in fact, there is some evidence that there may be a reverse response.

Table 10: Parental responses

	Material investment				Time investment - child			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Leave-one-out Combined VA	0.124***				0.044			
	(0.025)				(0.028)			
Leave-one-out Class VA math		0.102***		0.049		0.073**		0.113***
		(0.026)		(0.032)		(0.028)		(0.035)
Leave-one-out Class VA Viet			0.116***	0.088***			0.001	-0.067*
			(0.025)	(0.032)			(0.028)	(0.035)
Observations	1389	1354	1345	1310	1389	1354	1345	1310
R^2	0.142	0.142	0.136	0.142	0.036	0.040	0.034	0.042

Notes: All regressions control for dummies for maternal education, household wealth, and cohort fixed effects. *** p<0.01, ** p<0.05, * p<0.1.

5.3 Discussion

What does this add up to? Our Production Function estimates suggest that school inputs and parental material investments are substitutes in production of math skills. Then the optimal response for parents in response to an improvement in quality of math teaching would be to reduce material investments. However, despite evidence which suggests that they have “correct” beliefs about the quality of math teaching that their child receives, they nevertheless increase rather than decrease material investments in response to an increase in class quality.

Can we interpret this as evidence of incorrect beliefs about the interactions between investments in the PF? What implications does this have for interpretation of estimates in the child development literature (which only looks at home inputs) and the school Value Added literature (which only looks at school inputs)? What implications does it have for school policy - e.g. government investment in school quality won't crowd out home investment.

6 Conclusions

In this paper we estimate the production function of math and language achievement in Vietnam. We allow these skills to depend on both school and home inputs, which can be either substitutes or complements.

We find that, if anything, school and home inputs are substitutes. As a result, we would expect that in response to an increase in school inputs, parents would invest less in their children at home, since the productivity of home investments is smaller. However, we observe that the opposite happens.

This result suggests that parents have biased beliefs about the technology of skill formation.

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