# Socioeconomic status at the age of 1 predict opportunities to learn and achievement in mathematics in fourth grade in Peru

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**Abstract**

Using Young Lives longitudinal data from Peru, this paper explores the relationship between socioeconomic status (SES) measured at the age of 1, opportunities to learn (OTL) and achievement in mathematics by the time children were in fourth grade of primary school. Four variables of OTL were measured: hours of class per year, curriculum coverage, quality of teachers' feedback, and level of cognitive demand. The last three were measured through an analysis of the exercises attempted by students in their notebooks and workbooks. Multivariate analysis showed a robust association of one of the OTL variables (curriculum coverage, more specifically number of exercises attempted by students) with achievement in mathematics. Moreover SES at the age of 1 was significantly associated with this variable and with achievement by the time students were in fourth grade. Overall, the findings of the paper illustrate a highly unequal educational system in which relatively poor children have fewer OTL in school.

**Keywords:** *opportunities to learn, mathematics achievement, educational inequality, primary education, Peru.*

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## 1. Introduction

Enrolment rates in Peru at primary level are above 90% (Consejo Nacional de Educación, 2013). However, all standardised evaluations show a combination of low averages and a strong association between achievement and socioeconomic status (SES; e.g. OECD, 2010). National evaluations have shown similar results over the years, with higher achievement for students from urban, Spanish-speaking contexts, who attend private (fee-paying) schools (Cueto, 2007). This suggests an association between individual and family characteristics of students and their educational outcomes. While there have been several studies on the determinants of achievement, all of these have been cross-sectional and have usually observed inequalities in educational processes in the classroom that mirror the results achieved by groups of students observed (e.g. Cueto, Ramirez & León, 2006). In this paper we analyse the links between students' individual and family characteristics at around the age of 1, their opportunities to learn (OTL) and their achievement in mathematics when they were around the age of 10. To do this we take advantage of the Young Lives study, which includes data from three rounds of a household survey and one round of a nested school survey.

### *1.1 Inequality in educational opportunities and outcomes*

Most of the research on educational inequalities in developing countries such as Peru has focused on the link between educational outcomes and students' background variables (e.g. ethnic origin, type of school and parents' educational level). These studies have shown that from an early age there are significant differences in students' cognitive skills and mathematics performance that are closely linked with SES (e.g. Baltra, 2010; Treviño, Valdés, Castro, Costilla, Pardo & Donoso, 2010).

There are fewer studies on inequality of educational opportunity within schools (possibly due to the complexity of the variables). Some studies have shown that students' background is associated with school variables such as infrastructure, climate, management and educational materials available (e.g. Glewwe, Hanushek, Humpage & Ravina, 2011; Paxson & Schady, 2002; Treviño *et al.*, 2010); and is also associated with teacher variables such as subject matter knowledge, provision of tutoring, qualifications and school attendance (e.g. Glewwe *et al.*, 2011; Treviño *et al.*, 2010). Regarding the quality of teachers, some studies have found that students of lower SES have access to less qualified teachers (e.g. Akiba, LeTendre & Scribner, 2007; Cabezas, 2011).

Low and unequal mathematics learning have been topics of high academic and policy interest. There are programmes that have shown a strong impact on learning, such as CGI (Cognitively Guided Instruction). This is a primary school mathematics programme to help teachers understand students' mathematical thinking and tailor instructions to each student. CGI has been shown to have an effect on teachers' beliefs and practices (leading to better understanding of students' thinking, more comprehensive knowledge of mathematics and curriculum, and more capacity to apply pedagogical resources), and on student learning and achievement, especially related to problem-solving (Carpenter, Fennema, Franke, Levi & Empson, 2000).

Given these results, it becomes relevant to understand not only the achievement outcomes of students, but also the learning processes that take place in their classrooms. Efforts to close achievement gaps through improvements in educational processes (at the school, teacher and student levels) have shown promising results in favour of students from well-off families (Balfanz, & Byrnes, 2006; Lee, Franco & Albernaz, 2009).

### *1.2 Opportunities to learn*

The International Association for the Evaluation of Educational Achievement (IEA) developed the concept of OTL (McDonnell, 1995). The main idea is that differences in curriculum content and its coverage in classrooms may help explain students' achievement. Several methods have been used to assess OTL. These include interviews and surveys on curriculum coverage with students and teachers (Aguirre-Muñoz & Boscardin, 2008; Boscardin, Aguirre-Muñoz, Stoker, Kim, Kim & Lee, 2005; Cervini, 2001; Shriberg, 2006; Zambrano, 2002), classroom observations (Herman & Abedi, 2004; Pianta, Belsky, Houts & Morrison, 2007) and content analysis of material such as notebooks, workbooks and teachers' diaries (Kolovou, van den Heuvel-Panhuizen & Bakker, 2009; Törnroos, 2004, Ruiz-Primo, Li & Shavelson, 2001). In Peru, a few studies based on analysis of students' mathematics notebooks and workbooks have focused on four dimensions of OTL: percentage of correct answers to teacher-provided exercises, teachers' feedback, curriculum coverage and level of cognitive demand implicit in the exercises (e.g. Cueto *et al*., 2006).

Studies conducted in the USA have found a positive association between OTL and academic achievement (Aguirre-Muñoz & Boscardin, 2008; Boscardin *et al*., 2005; Herman & Abedi, 2004; Shriberg, 2006; Törnroos, 2004). For example, higher levels of content coverage have been positively associated with students' academic performance (Aguirre-Muñoz & Boscardin, 2008; Boscardin *et al*., 2005; Törnroos, 2004). Some studies in Canada and the USA show that teachers prioritise exposure to basic levels of learning, with little emphasis on problem-solving or mathematical reasoning skills (Jaafar, 2006; Pianta *et al*., 2007). A small proportion of the exercises in students' textbooks had high levels of cognitive demand (Kolovou *et al*., 2009).

In Latin America, recent studies in Chile (Ministerio de Educación de Chile [MINEDUC], 2004), Argentina (Cervini, 2001) and Peru (Cueto *et al*., 2006; Zambrano, 2002) have found an association between learning opportunities and academic performance. Most show that curriculum coverage is lower than would be expected, given the content of national curricula. The topic covered more often by teachers in Peru was numeracy (Cueto *et al*., 2006; MINEDUC, 2004; Zambrano, 2002). Students who attempted more exercises with higher levels of cognitive demand performed better academically (Cueto *et al*., 2006; MINEDUC, 2004). However, as mentioned above, all these studies have been cross-sectional. In this paper we explore whether the socioeconomic characteristics of a child at an early age are associated with OTL and achievement in mathematics by the time children are in fourth grade. In this paper we define OTL with four variables—curriculum coverage, hours of mathematics at school per year, quality of teachers' feedback and level of cognitive demand—and analyse its relation with students' SES and achievement.

## 2. Design and methods

In this study we analyse the OTL of Young Lives children of different SES and explore its association with mathematics achievement, controlling for several covariates. The interaction between OTL and students' SES is relevant because if found to be positive and significant, it would show a compounding effect of school and home disadvantage for poorer children. Our data derive from the first three rounds of the Young Lives household survey (i.e. 2002, 2006, and 2009) as well as the Young Lives nested school survey (2011).[1] The wealth index, assessed in Round 1, when children were between 6 and 18 months of age, was used to divide the sample into three study groups (terciles) of equal size: low SES (first tercile), medium SES (second tercile) and high SES (third tercile). This index was formed based on information about housing quality, ownership of durable assets, and access to basic services.

### *2.1 Sample*

We planned to collect mathematics notebooks and workbooks from up to two randomly selected Young Lives children in the fourth grade per school from a sub-sample of 80 schools selected at random from the nested school survey's total sample (132 schools). By design, Young Lives excluded from the original sample the 5% wealthiest districts in Peru (see Escobal & Flores, 2008). Because results presented below do not include students who attend expensive private schools, which are generally located in those districts, the differences between SES terciles in OTL and achievement reported in this study are probably underestimated for the country.

During the fieldwork, some Young Lives children from the original sample were not found at their schools, were not enrolled in fourth grade, or did not have their mathematics materials available. This reduced the original sub-sample of 80 schools to 66 (for a total of 102 students); the workbooks and notebooks of all 102 students were collected and photocopied towards the end of the 2011 school year.

Table 1 shows the number of fourth grade students by type of school: private, which requires tuition fees; and three types of government schools, which do not require tuition fees. These are urban, rural with Spanish teaching and rural with Intercultural-Bilingual Education (EIB Model), for indigenous populations. Private and government urban schools teach their lessons in Spanish.

[Insert Table 1 here]

*2.2 Measures*

Table 2 shows the characteristics of the students, schools and teachers measured in this study.

[Insert Table 2 here]

In addition, we measured four OTL variables corresponding to three dimensions previously identified in the literature: (i) content coverage and emphasis, (ii) content exposure, and (iii) Quality of instruction (Wang, 1998). Each variable was measured based on exercises found in the notebooks and workbooks, except hours of class per year, which was reported by the headteacher. A mathematics exercise was defined as a task that required an answer, posed by teachers to students. The OTL dimensions and variables are presented in Table 3.

[Insert Table 3 here]

Figure 1 shows examples of exercises we found in students' notebooks and workbooks coded as 'low cognitive demand'. In exercise (a) students were asked to write in words numbers from 100,000 to 150,000, counting by 50; for exercise (b) students were asked to write the word 'rectangle' repeatedly; and for exercise (c) students were asked to calculate divisions. Exercises (a) and (b) are presented to give examples of the lowest levels of cognitive demand found, while exercises like (c) were the most common (with similar exercises on addition, subtraction and multiplication). As shown in Figure 3, the lowest level of cognitive demand was the most frequent in the classrooms. These are also very simple exercises for students, but take a long time to be completed.

[Insert Figure 1 here]

By contrast, Figure 2 presents an example of an exercise coded as 'high cognitive demand'. In this exercise students are asked to indicate if the second shape represents symmetry or translation, and to justify their answer. Unlike the previous exercises, this one cannot be solved through the application of routine procedures, but needs students to understand the definitions provided and provide a justification for their answer.

[Insert Figure 2 here]

### *2.3 Procedures*

As part of the Young Lives nested school survey, towards the end of the 2011 school year we collected students' notebooks and workbooks, and administered questionnaires to the headteachers and mathematics teachers, and mathematics tests to the students. Notebooks and workbooks were analysed and coded by a trained team of encoders at GRADE (for more information on coding procedures and reliability, see Cueto, Guerrero, León, Zapata & Freire, 2013). Data relating to the families' SES (Round 1) and the children's prior knowledge of notions of quantity (Round 2, before they had started school) were used in the analysis. Time-invariant demographic variables (e.g. gender) were verified at each survey round in order to ensure consistency of the information.

## 3. Results

### *3.1 Characteristics of the students and the schools*

The results presented in Table 4 compare students by terciles according to the wealth index assessed in Round 1 of the Young Lives survey. The table presents information about the characteristics of the students and their families. Students' ages were very similar in the three socioeconomic groups. In the first (poorest) and third (richest) terciles male students predominated. Less than 20% of the total sample had an indigenous mother tongue, although the percentage is highest for the first tercile and 0 for the third tercile. CDA scores are higher for the third tercile, which suggests that before starting primary school they had already exhibited more highly developed quantitative skills. There are pronounced differences in the parents' education level by tercile. While the average score on the wealth index improved for all groups between rounds, the differences between the terciles were very similar in Rounds 1 and 3.

[Insert Table 4 here]

Table 5 presents school and teacher characteristics. Students in the third tercile are most likely to attend a private school, students from the second tercile are most likely to attend government schools in urban areas, and students in the first tercile are most likely attending rural schools (either bilingual or in Spanish only). Students from the third tercile attended schools with better infrastructure. All students from the third tercile attended schools with access to all public services and approximately 90% of these students attended schools that had internet and telephone services. While most of the schools in the first tercile had electricity, they were less likely to have water and sanitation facilities, and access to telephone and internet services. This suggests inequality in the provision of school infrastructure.

Even though headteachers reported similar numbers of days with classes during a year, instruction time is reported to be slightly higher for the third tercile (see Figure 4). In relation to teacher characteristics, most were women and fewer than 22% had an indigenous mother tongue, with the highest concentration of these in the first tercile and none in the third tercile. In addition, students in the first tercile had teachers with fewer years of experience.

[Insert Table 5 here]

### *3.2 Curriculum coverage*

Figure 3 shows that, regardless of the socioeconomic tercile, the content domain with the most exercises attempted in fourth grade was numeracy, while the one with the fewest was measurement and statistics. Furthermore, students from the three terciles attempted a large number of exercises that did not correspond to the capacities included in the curriculum for the fourth cycle (third and fourth grades), but rather to the curriculum for previous or later cycles (including secondary) ,[2] suggesting, among other possible explanations, that teachers adapted the national curriculum to the achievement levels of the students or that teachers chose to teach the capacities and content with which they themselves felt comfortable or believed were more important for students.

Figure 3 also shows that students from the third tercile attempted more exercises during the school year (1,686), almost twice the number of exercises attempted by students from the second tercile (898) and almost three times the number attempted by students from the first tercile (670). While this may be due to the teachers' perceptions of what students can do, the fact is that students of poorer SES have fewer opportunities to practise mathematics. In the multivariate analysis below we explore if this is associated with achievement.

[Insert Figure 3 here]

*3.3 Hours of class per year*

Information about the number of hours devoted to mathematics was not available in the school survey; however, we were able to estimate the total number of hours of classes (considering all subject areas) for the year as reported by headteachers. This figure should be a good proxy for content exposure in mathematics, as well as all other subject areas. Figure 4 presents the number of hours of class per year for the three terciles. The results suggest Peruvian students have on average slightly less than 900 hours of classes (60 minutes) per year.

[Insert Figure 4 here]

*3.4 Quality of teachers' feedback*

Figure 5 shows the proportion of exercises with correct feedback out of all the exercises attempted by students. The pattern is similar across socioeconomic terciles. Around one-third of the exercises attempted by students in their workbooks and notebooks received correct feedback from the teacher, a very small proportion received incorrect feedback and over 60% of exercises across terciles did not receive any written feedback from the teacher.

[Insert Figure 5 here]

*3.5 Level of cognitive demand*

Given the emphasis that the national curriculum and evaluations place on problem-solving, it was expected that students' notebooks and workbooks would show many exercises with relatively high levels of cognitive demand. However, as shown in Figure 6, this was not the case. Even though differences in percentages between terciles are quite small, students from the highest socioeconomic tercile attempted more exercises with higher levels of cognitive demand (given that, as shown in Figure 3, they were asked to solve considerably more exercises than students in the other terciles).

[Insert Figure 6 here]

*3.6 Association between OTL and mathematics achievement*

This section presents data on the relation between OTL and achievement. Figure 7 presents the average mathematics achievement of each SES tercile. SES at the age of 1 predicted achievement ten years later, by the time students were in fourth grade. The differences between terciles on average are large: almost one standard deviation between the first and second terciles, and 0.6 of a standard deviation between the second and third terciles. Nevertheless it should be noted that there is a significant overlap between adjacent groups (percentiles 10 and 90), demonstrating the high variability in student performance. Below we explore if some of this variation is associated with OTL.

[Insert Figure 7 here]

Table 6 shows the correlation between the OTL variables. There is a positive and statistically significant correlation between curriculum coverage (the number of exercises attempted by students) and two other OTL variables: number of hours of classes per year and level of cognitive demand. The feedback provided by teachers to the exercises attempted by students is not associated with the other OTL variables. We are not arguing that feedback is not an important OTL variable; possible explanations for this finding are discussed later.

[Insert Table 6 here]

*3.7 Multivariate analysis*

In order to control for confounding effects on students' achievement, a regression analysis was performed. This analysis permitted the estimation of the net effect of each OTL variable once individual, family, teacher and school characteristics were held constant. Since student achievement is a continuous variable that reflects the level of students' mathematical skills, a multivariate regression model was estimated using Ordinary Least Squares, adjusting the covariance matrix for the possible covariation of students attending the same school. Control variables included in the model are related to child and family demographic characteristics, and students' prior abilities. Additionally, we included variables related to teachers' and schools' characteristics.

Table 7 shows the different models estimated. Models 1 to 4 present the effect of each OTL variable on students' achievement, indicating a positive and statistically significant association of curriculum coverage (number of exercises attempted) and level of cognitive demand with achievement in mathematics. Model 5 shows the effect of the wealth index, which is highly significant, while Model 6 presents the combined effect of OTL variables, in which number of exercises and level of cognitive demand remain significant. For Model 7 we added the effect of the wealth index and found that only the effect of the number of exercises remains significant.

We then explored if the effect was robust to the inclusion of additional control variables. In Model 8 we added several covariates, but as shown only the number of exercises remained as a significant predictor of achievement. It is interesting to notice that students' prior abilities (CDA scores) do not have a significant association with achievement (see Annex). Although their correlation with achievement is positive and significant ($r=0.25$, $p<0.05$), when incorporating the wealth index the effect disappears. Model 9 shows no significant interaction between OTL variables and the wealth index. In Models 8 and 9 the wealth index at the age of 1 is non-significant; this is explained by the inclusion of maternal education as a control variable (see Annex), which is also a variable that reflects the SES of the family, similar to the wealth index.

[Insert Table 7 here]

## 4. Discussion and policy implications

Our analysis of OTL for Peruvian students shows a wide discrepancy from what was intended in the national curriculum. An average Peruvian student solves mostly numeracy exercises of low cognitive demand, without receiving feedback from his or her teacher for the majority of exercises. However, the number of hours of class per year would seem to be above the average of OECD and some Latin American countries (OECD, 2011).

Given previous studies in Peru (Cueto *et al.*, 2006) and other countries (e.g. MINEDUC, 2004), the emphasis on numeracy seems to be a strong finding that would merit policy interventions on how to increase coverage of other content domains. For cognitive demand, our results show that teachers generally present students with exercises that only require the application of procedures in routine ways (i.e. low cognitive demand). As a reference, in the TIMSS mathematics test for fourth grade 20% of the items are at the highest level of cognitive demand (i.e. reasoning; IEA, 2003); in our study fewer than 5% of exercises were at this level.

Regarding the links between OTL and SES, to our knowledge this is the first time that OTL has been linked with a measure of wealth at the age of 1. The association was positive and significant, thus depicting a highly unequal system of education in which from an early age the quality of instruction 10 years later can be predicted. This seems to be reinforced by an unequal provision of basic school services.

The differences in OTL among SES groups are particularly marked when we compare the number of mathematics exercises attempted by students. Children from the highest socioeconomic tercile attempted almost three times as many exercises as their peers from the lowest tercile. However, we did not find statistically significant differences among groups in the number of hours of classroom time or the average level of cognitive demand and the proportion of exercises with correct feedback provided by teachers. The absence of differences in classroom time perhaps is explained by the strong emphasis of the Ministry of Education in these past few years on the need for primary schools to complete 1100 pedagogical hours per year (each pedagogical hour should be planned for 45 minutes, for a total of 825 chronological hours per year approximately). Regarding the average level of cognitive demand and the proportion of exercises with correct feedback, while there is no difference by SES for these variables, there is a large difference in the number of exercises, given that students from the highest SES tercile do many more exercises than those from the lowest tercile. In other words, if we look at the number of exercises it is very clear that students of lower SES have less OTL in these two variables (level of cognitive demand and proportion of exercises with correct feedback) than their better-off peers.

Regarding the links between OTL and SES and student achievement, our findings show that two OTL variables (curriculum coverage— the number of exercises attempted by students— and the level of cognitive demand) are positively associated with student achievement. For the interpretation it is relevant to remember that the number of mathematics exercises attempted is positively correlated with the average level of cognitive demand. In other words, those students who were able to work on more exercises during a school year were also more likely to encounter exercises of higher cognitive demand. This is an interesting result and it supports the idea that OTL should be conceptualised as a global construct (Cervini, 2001; Wang, 1998), with specific indicators that we may have captured only partially in this study. Additionally, we found that SES at the age of 1 was also positively associated with student achievement, and the association remained statistically significant even after introducing OTL variables. However, once we included several covariates (child, family, teacher and school variables), only the association between the number of exercises attempted by students and their achievement remained significant. Although number of exercises attempted by students is statistically significant, number of hours of classes per year is not significantly associated with achievement. This suggests that it is not only the time in class that matters but the amount of pedagogical work that is completed in the classroom.

One of the objectives of this paper was to study whether OTL interacted with students' SES, in order to explore if providing students with better OTL could be a way to address socioeconomic gaps. Our results show that the interaction between the OTL variables and SES was not significant. Nevertheless other studies in Latin America have found that improving educational processes could help address socioeconomic achievement gaps (Lee *et al.*, 2009). The issue of how to raise achievement and at the same time reduce gaps between richer and poorer students remains an important topic for research.

Overall we believe that our results contribute to the literature on OTL by showing that the differences in achievement by SES groups can be linked also with what happens inside the mathematics classroom; what is novel about this three-way link is that OTL and achievement for Peruvian students may be predicted by SES measures taken at the age of 1. Secondly, this study reinforces the importance of taking direct measures of OTL, in particular the number of exercises attempted as a measure of curriculum coverage and the level of cognitive demand, as a measure of quality of instruction. Although we did not find a robust association of level of cognitive demand with achievement, we believe it is worth continuing to explore this since critical thinking has been proven to be associated with higher levels of achievement in mathematics through educational interventions such as CGI (Carpenter *et al*., 2000). We are not arguing however that all exercises should be at the highest level of cognitive demand. It would seem obvious for example that there is a need for definitions of concepts and for practice of routine exercises in order for students to develop expertise. Third and finally, while most studies measure OTL at the classroom level, in this study we have collected data for individuals, considering that OTL within a classroom may vary; we did not have enough variation within classrooms in this study to explore this topic, but it would seem a relevant area for further research.

Regarding the other OTL variables (time in the classroom and teacher feedback), it would seem that given previous studies they should both be associated with achievement; the lack of significant results merits some discussion. For time in class, our first inclination is to find ways of registering this independently of the report of a headteacher, who may bias reports for social desirability. While important, this is a difficult task in countries like Peru that have very few external monitors visiting schools. Regarding feedback, we are not arguing it is not an important OTL variable, but perhaps feedback provided in workbooks and notebooks is not as effective as feedback provided in ways that were not measured here (e.g. feedback provided to responses to a test or face to face in the classroom). The type of feedback may also matter. For example, previous studies show that specific feedback on how to solve a task seems to be more effective than praise, extrinsic rewards, or punishment (Hattie & Timperley, 2007), and feedback in the form of short written comments improved students' test performance when compared with just grades (Page, 1958). Moreover, the combination of oral and written feedback would seem to be more effective than written feedback alone (Bitchener, Young & Cameron, 2005).

While we have found that the number of exercises attempted shows a higher association with achievement, this does not exclude the relevance of teachers' decision-making on pedagogical issues. For example, it may be that teachers plan the number of exercises based on the academic abilities of students, i.e., doing fewer exercises with weaker students may be justified pedagogically. However, the fact remains that poorer children do fewer exercises in a year and perform worse than their better-off counterparts. If this is the case, increasing OTL would need to be tackled in previous grades or even in preschool, so that there would be fewer differences in abilities and OTL by fourth grade. From another perspective, it may be that teachers of poorer students spend less time effectively teaching in the classroom (as shown above, time at school seems to be similar), and this is why they do fewer exercises. There is some evidence of time loss in Peru that suggests that indeed this may be the case (Cueto, Jabcoby & Pollit, 1997), but as mentioned above we have no direct measurements of time spent in the classroom learning in this study.

Finally, we realise that an analysis of workbooks and notebooks does not capture all pedagogical interactions within the classroom; many teacher explanations, discussions and demonstrations go unrecorded in these materials. However, we still think that coding students' materials is a valid and objective method to measure OTL (to begin with, the association with achievement shown above and in other studies is positive). The method could be further developed in other studies and complemented with other measurements, based on conceptual considerations of what OTL may entail and how they may relate to both increasing averages and reducing inequalities in achievement.

Regarding policy implications, while SES is not a variable that could be easily modified by policymakers, OTL may be an instrument to raise achievement. We think that there is enough information accumulated from OTL studies, particularly in Latin America (e.g. MINEDUC, 2004; Cervini, 2001; Cueto *et al*., 2006), to suggest that an intervention could be planned and its impact evaluated rigorously, so as to assess cause and effect links (for example, through a randomised controlled trial). Such an intervention could focus on all aspects of OTL, from those described above to others deriving from theoretical considerations of learning, but it would seem that a focus on working with teachers on ways to work intensively, increase the level of cognitive demand of the exercises, and teach other topics of the curriculum (not only numeracy) would be particularly promising.

Other potential avenues for reform include a revision of the national curriculum, along with an improved teacher education programme on mathematics pedagogy (see for instance Tatto, Lerman & Novotna, 2010). While we have no data on alignment of different pedagogical instruments (e.g. the curriculum, teacher pre- and in-service programmes, textbooks used in classrooms and national evaluations) in this study, this would also seem a potentially interesting topic for work given the distance between the observed and implemented curriculum described above.

Finally, monitoring systems within schools could be enriched by including OTL indicators. For example, well-trained school supervisors could analyse samples of students' work and discuss with teachers at schools how to increase students' OTL. If teachers were provided with immediate feedback on their work, it may well be that mathematics lessons would be more inspiring for all participants. This would require, however, the development of objective and valid methods to quickly assess OTL during routine visits.

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**Notes**

1. For information about the nested school survey design and initial findings, see Guerrero, León, Rosales, Zapata, Freire, Saldarriaga & Cueto (2012).
2. For a detailed description of the capacities that are not included in the fourth cycle curriculum, see Cueto et al. (2013).

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**Tables and figures**

Table 1. Distribution of students in the sample by type of school

| | | Students | | Schools | |
|---|---|---|---|---|---|
| | | N | % | N | % |
| Private | Urban | 17 | 16.3 | 13 | 19.7 |
| Government | Urban | 48 | 46.2 | 29 | 43.9 |
| | Rural | 12 | 11.5 | 7 | 10.6 |
| | EIB Rural | 27 | 26.0 | 17 | 25.8 |
| Total | | 104 | 100.0 | 66 | 100.0 |

Source: Young Lives school survey (2011). Own elaboration.

Table 2. Measures of the characteristics of the students, schools and teachers measures in the study

| Measure | Definition |
| --- | --- |
| Students' demographic and socioeconomic information | Characteristics of students and their families from Round 1 (i.e. mother tongue, parents' education and wealth index) |
| School and teacher characteristics | Information from the nested school survey's 'Headteacher questionnaire' (timetables, infrastructure, access to basic services and instructional time at school), and 'Mathematics teacher questionnaire' (teacher's age, gender, mother tongue and years of teaching experience) |
| Students' prior abilities | Children's scores (standardised) on tests taken before they started school, administered in Round 2 when they were around 5 years old. Young Lives used the Quantitative sub-test of the Cognitive Development Assessment (CDA), a test developed by the IEA for an international study. (For further information, see Cueto, Leon, Guerrero & Muñoz, 2009.) |
| Mathematics achievement | Students took a mathematics test to measure their abilities in numeracy (37 items on arithmetic and problem-solving). Item Response Theory (ITR) was used to construct students' scores. Rasch modeling was used for calculating and calibrating the scores and then, using as reference the average score of fourth-grade students, the mean was set at 300, with a standard deviation of 50. |

Table 3. Opportunity to learn (OTL) variables used in the study

| OTL dimension | OTL variables | Definition | Indicator |
| --- | --- | --- | --- |
| Content coverage and emphasis | Curiculum coverage | We used the national curricular framework (Ministerio de Educación del Perú [MINEDU], 2009) to identify the content domains that all teachers were expected to cover in mathematics. Four content domains were included: (a) numeracy, (b) geometry, (c) measurement, and (d) statistics. Through the analysis of students' notebooks and workbooks, each exercise was coded as belonging to one of these content domains. To do this we elaborated a curricular framework, which included primarily capacities corresponding to the fourth cycle of Regular Basic Education (third and fourth grades of primary). | Total number of exercises attempted by students in their notebooks and workbooks (by domain and for all domains combined) |
| Content exposure | Hours of class per year | This variable was built with the number of days of class per year (excluding programmed holidays at each school) multiplied by the number of pedagogical hours per day, and by the number of minutes a pedagogical hour lasted, all divided by the number of minutes in a chronological hour. | Number of chronological hours of class per year |
| Quality of instruction | Proportion of exercises with correct feedback | Each exercise received a code on the feedback given by the teacher (or the absence of it). Correct feedback was defined as any type of mark from the teacher indicating that the answer was right or wrong that was appropriate, given the student's response. | Proportion of exercises with correct feedback in relation to the total of exercises attempted by students |
| | Cognitive demand of exercises | Cognitive demand is the level of mental processing required to solve exercises. The coding of each exercise was based on the TIMSS (Trends in International Mathematics and Science Study) framework (IEA, 2003), which classifies students' behaviours into four cognitive domains: (a) knowing facts and procedures, (b) using concepts, (c) solving routine problems, and (d) reasoning. In this test students are expected to attempt exercises corresponding to the four levels; lower levels of cognitive demand are the foundation for the higher ones (e.g. in order to solve a complex problem students still need to recall and use concepts). | Average cognitive demand for all exercises in students' notebooks and workbooks |

Note: We also coded the proportion of correct exercises solved by the student; however, it was not included in the analysis given the endogenous nature of the variable. It had a positive and statistically significant correlation with mathematics achievement ($r=0.34$, $p<0.01$) and could be used as a pedagogical tool for monitoring by teachers (see Cueto *et al.*, 2013).

Table 4. Students' characteristics by socioeconomic terciles (standard deviation)

| | First tercile (n=34) (lowest) | Second tercile (n=34) | Third tercile (n=34) (highest) |
|---|---|---|---|
| Female (%) | 44.1 | 61.8 | 29.4 |
| | (50.4) | (49.3) | (46.2) |
| Age (months) | 118.5 | 118.8 | 118.4 |
| | (3.3) | (3.1) | (2.7) |
| Indigenous mother tongue (%) | 32.4 | 23.5 | 0.0 |
| | (47.5) | (43.1) | (0.0) |
| CDA Quantitative sub-test standardised score (Round 2) | 276.0 | 287.2 | 318.4 |
| | (57.8) | (42.9) | (49.3) |
| Mother completed secondary school (%) (Round 2) | 5.9 | 23.5 | 73.5 |
| | (23.9) | (43.1) | (44.8) |
| Father completed secondary school (%) (Round 2) | 26.5 | 38.2 | 76.5 |
| | (44.8) | (49.3) | (43.1) |
| Wealth index (Round 1) | 0.2 | 0.4 | 0.6 |
| | (0.1) | (0.1) | (0.1) |
| Wealth index (Round 3) | 0.4 | 0.5 | 0.7 |
| | (0.1) | (0.2) | (0.1) |

Source: Young Lives survey rounds 1 (2002), 2 (2006) and 3 (2009). Own elaboration.

Table 5.School and teacher characteristics by socioeconomic terciles

| | First tercile (n=34) (lowest) | Second tercile (n=34) | Third tercile (n=34) (highest) |
|---|---|---|---|
| Type of school (%) | | | |
| Government | 100.0 | 91.2 | 58.8 |
| Rural | 73.5 | 38.2 | 0.0 |
| EIB Rural Government | 50.0 | 26.5 | 0.0 |
| Infrastructure (%) | | | |
| Library | 41.2 | 44.1 | 55.9 |
| Playground/field | 41.2 | 61.8 | 47.1 |
| Dispensary | 0.0 | 2.9 | 8.8 |
| Basic services (%) | | | |
| Electricity | 91.2 | 94.1 | 100.0 |
| Piped water | 41.2 | 70.6 | 100.0 |
| Sanitation | 11.8 | 58.8 | 100.0 |
| Telephone | 14.7 | 35.3 | 91.2 |
| Internet | 20.6 | 35.3 | 88.2 |
| Instruction | | | |
| Days of classes per year | 192.5 | 193.0 | 189.4 |
| Teacher | | | |
| Gender (female) | 72.7 | 69.7 | 58.8 |
| Mother tongue (indigenous) | 21.2 | 12.1 | 0.0 |
| Years of teaching experience | 12.7 | 19.8 | 16.4 |

Source: Young Lives school survey (2011). Own elaboration.

Table 6. Correlation between OTL variables

| | 1 | | 2 | | 3 | 4 |
|---|---|---|---|---|---|---|
| 1. Curriculum coverage | 1.00 | | | | | |
| 2. Hours of classes per year | 0.32 | ** | 1.00 | | | |
| 3. Proportion of correct teacher feedback | 0.03 | | -0.05 | | 1.00 | |
| 4. Level of cognitive demand | 0.21 | ** | 0.19 | + | 0.01 | 1.00 |

*** p<0.001, ** p<0.01, * p<0.05, $^{+}$ p<0.10

Source: Young Lives school survey (2011). Own elaboration.

Table 7. Effect of SES and OTL variables on mathematics achievement, controlling for additional characteristics (standardised coefficients)

| | Models | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | M1 | M2 | M3 | M4 | M5 | M6 | M7 | M8 | M9 |
| *Main effects* | | | | | | | | | |
| Number of exercises attempted | 0.44 *** | | | | | 0.39 *** | 0.19 + | 0.18 + | 0.20 + |
| Hours of classes per year | | 0.18 | | | | 0.01 | -0.02 | -0.10 | -0.05 |
| Proportion of correct teacher feedback | | | -0.03 | | | -0.05 | -0.06 | -0.07 | -0.03 |
| Level of cognitive demand | | | | 0.29 ** | | 0.20 * | 0.07 | -0.03 | -0.03 |
| Wealth index (WI) in 2002 | | | | | 0.57 *** | | 0.44 ** | 0.16 | 0.20 |
| *Interaction effects* | | | | | | | | | |
| Number of exercises attempted*WI | | | | | | | | | -0.04 |
| Hours of classes per year*WI | | | | | | | | | -0.09 |
| Proportion of correct teacher feedback*WI | | | | | | | | | -0.05 |
| Level of cognitive demand*WI | | | | | | | | | -0.11 |
| *Control variables* | | | | | | | | | |
| Individual, family and school | No | No | No | No | No | No | No | Yes | Yes |
| Observations | 102 | 102 | 102 | 100 | 102 | 100 | 100 | 98 | 98 |
| R-squared | 0.19 | 0.00 | 0.08 | 0.03 | 0.32 | 0.24 | 0.35 | 0.48 | 0.50 |

*** $p<0.001$, ** $p<0.01$, * $p<0.05$, + $p<0.1$

Note: Individual and family variables are gender, age, mother tongue, mother´s education, and number of siblings. School and instructional variables are location of school and type of school management. Teacher variables are age, gender, mother tongue and years of teaching experience.

Source: Young Lives school survey (2011). Own elaboration.

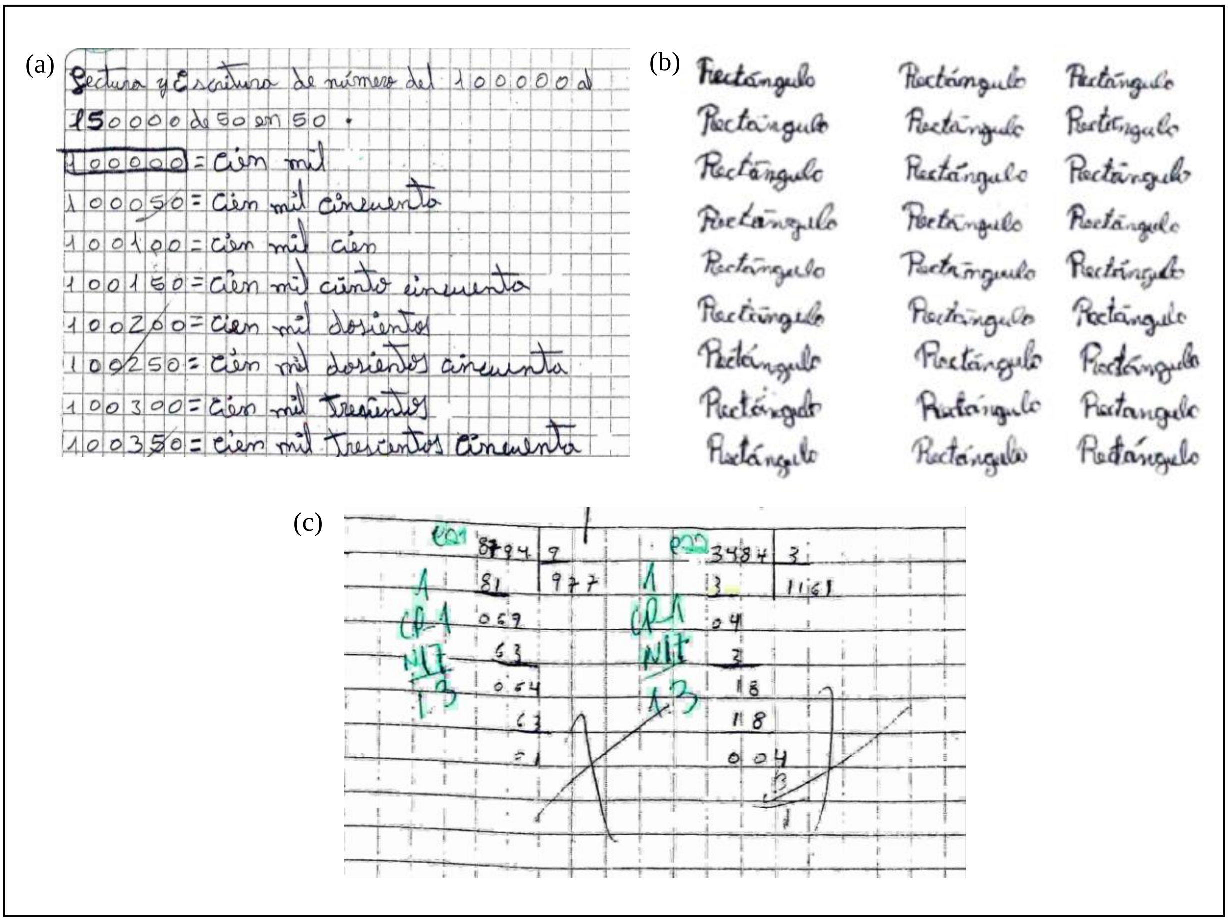


Figure 1. Examples of the cognitive domain ‘Knowing facts and procedures’: (a) reading numbers and writing them in words, (b) writing the word ‘Rectangle’ and (c) solving arithmetic exercises.

*Source*: Young Lives school survey (2011).


Figure 2. Example of the cognitive domain ‘Reasoning’. *‘Has a symmetry or a translation been performed? Why?’*

*Source*: Young Lives school survey (2011).

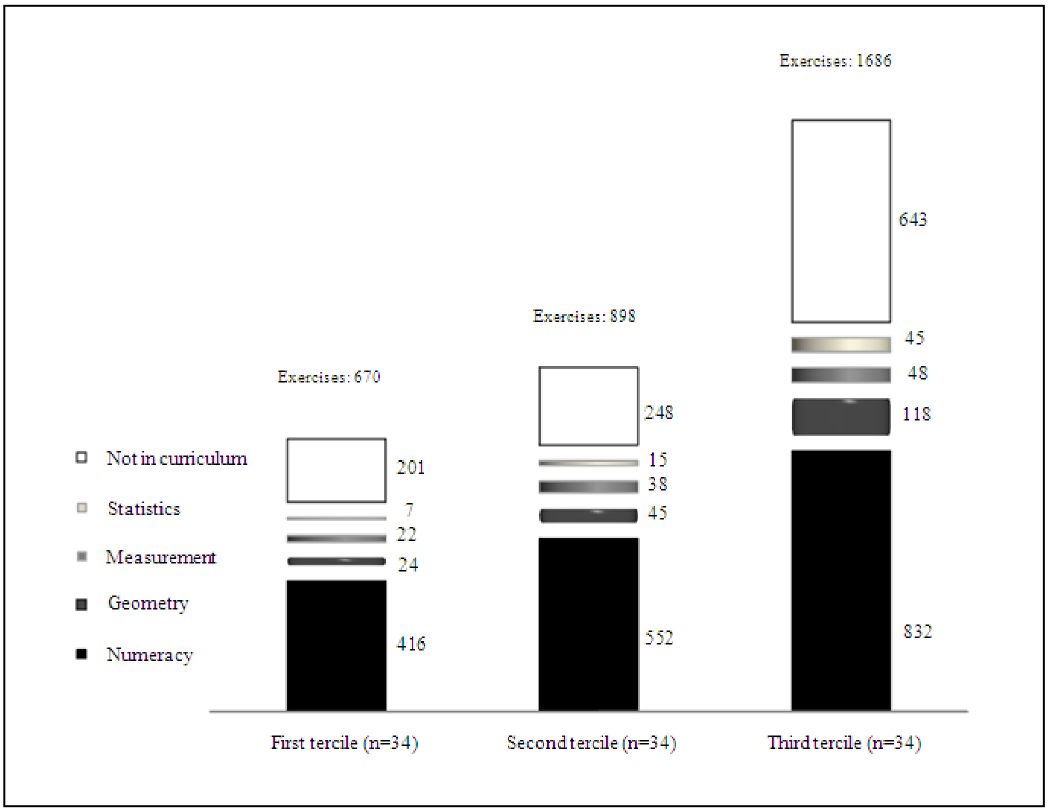


Figure 3. Number of mathematics exercises attempted by students, by content domain and socioeconomic tercile.

*Source*: Young Lives school survey (2011). Own elaboration.

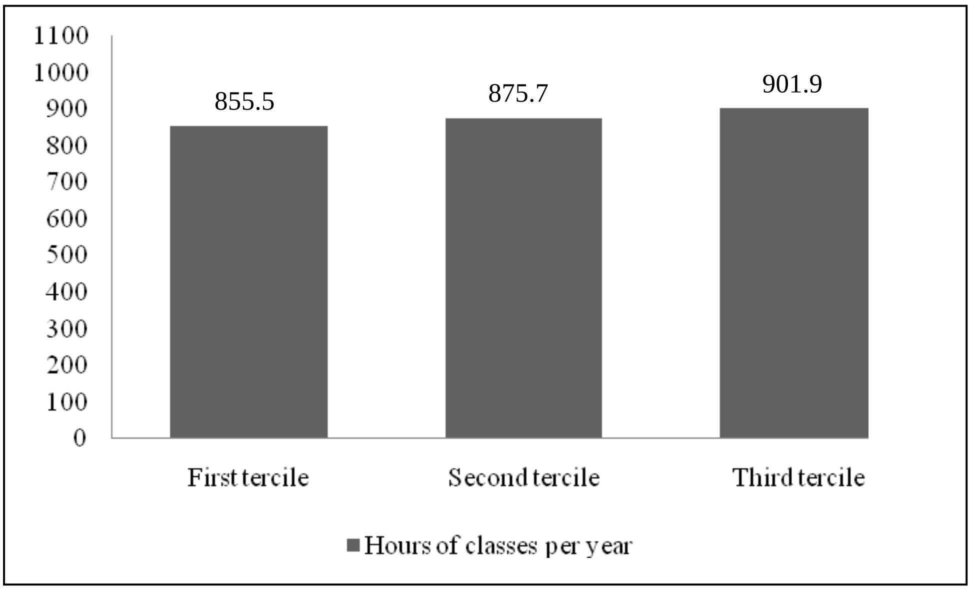


Figure 4. Number of hours of classes per year by socioeconomic tercile.

*Source*: Young Lives – reports from headteachers in the school survey (2011). Own elaboration.

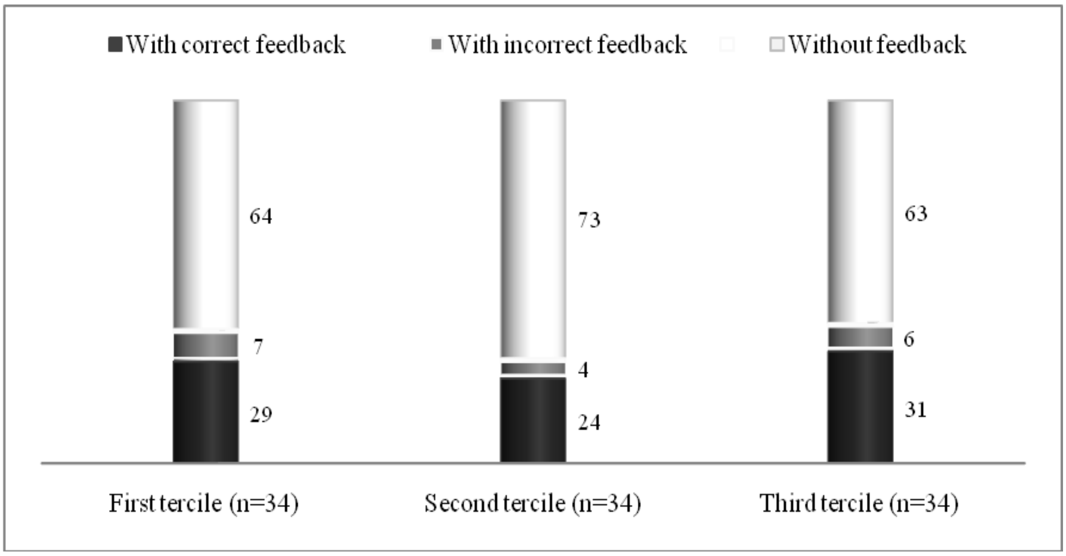


Figure 5. Proportion of exercises with correct feedback out of the total number of exercises attempted by students, by socioeconomic tercile.

*Source*: Young Lives school survey (2011). Own elaboration.

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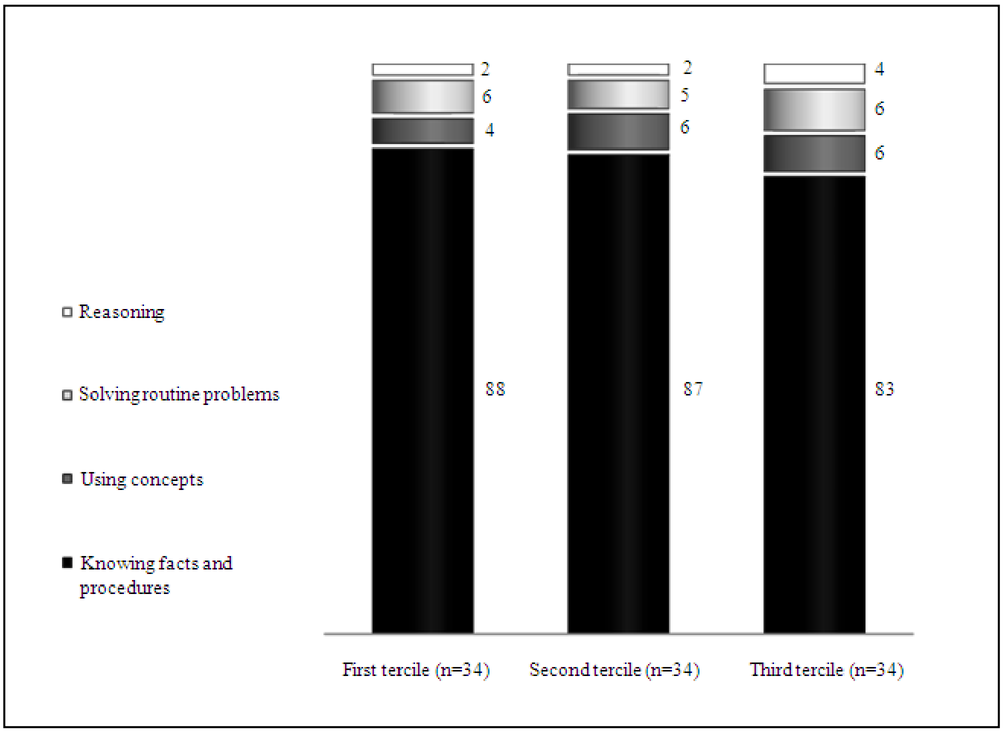
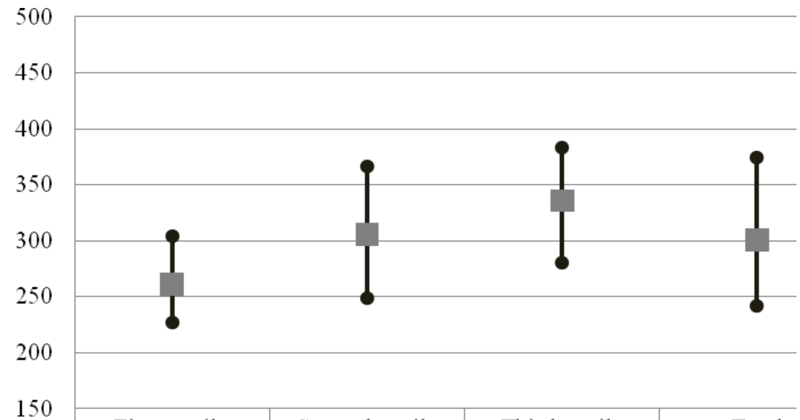



Figure 6. Level of cognitive demand of mathematics exercises, by socioeconomic tercile

*Source*: Young Lives school survey (2011). Own elaboration.



| | First tercile (n=34) | Second tercile (n=34) | Third tercile (n=34) | Total (n=102) |
|---|---|---|---|---|
| Percentile 90 | 304 | 367 | 383 | 375 |
| Percentile 10 | 227 | 249 | 281 | 242 |
| Average ■ | 261 | 306 | 336 | 301 |

Figure 7. Mathematics achievement by socioeconomic tercile

Note: Differences between socioeconomic terciles are statistically significant at 5% level according to Scheffe Test.

*Source:* Young Lives school survey (2011). Own elaboration.

**Annex**

Table A. Coefficients for control variables in Models 8 and 9 (standardised coefficients)

| | (8) | (9) |
|---|---|---|
| CDA Quantitative sub-test score | 0,02 | 0.03 |
| | (0.07) | (0.08) |
| Female | -0.17+ | -0.17+ |
| | (8.96) | (9.06) |
| Age (months) | 0.03 | 0.03 |
| | (1.47) | (1.59) |
| Mother tongue (indigenous) | 0.02 | 0.00 |
| | (9.76) | (12.04) |
| Mother´s education (secondary or more) | 0.31** | 0.28* |
| | (10.73) | (10.98) |
| Number of siblings | 0.05 | 0.06 |
| | (2.25) | (2.22) |
| Attends a government school | -0.17 | -0.23+ |
| | (14.86) | (16.38) |
| Attends a rural school | -0.19 | -0.12 |
| | (17.76) | (17.59) |
| Teacher´s age (years) | 0.11 | 0.08 |
| | (0.95) | (0.99) |
| Teacher is female | -0.03 | -0.01 |
| | (10.08) | (10.58) |
| Teacher´s mother tongue (indigenous) | 0.10 | 0.12 |
| | (12.63) | (13.75) |
| Teacher´s years of experience | -0.02 | 0.03 |
| | (0.99) | (1.04) |
| Observations | 98 | 98 |
| R-squared | 0.48 | 0.50 |

Robust standard errors in parentheses.

** p<0.01, * p<0.05, + p<0.1

Source: Young Lives school survey (2011). Own elaboration.