School Infrastructure and Educational Outcomes:
A Literature Review, with Special Reference to Latin America

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Abstract

International development agencies and country governments have called for greater resources to be devoted to education. While previous studies have highlighted the value of investing in education, they do not shed light on which specific educational investments should be pursued. This paper examines both the economics literature and the education literature published from 1990 to 2012 to assess the extent to which specific types of school infrastructure have a causal impact on student learning and enrollment. There is some evidence that school libraries and the creation of new schools leads to improved learning and enrollment. The literature also provides some evidence that toilets improve student learning, and that laboratories and drinking water facilities increase enrollment. Perhaps the main conclusion of this study is that the evidence base is weak, so more high quality research is needed on the impact of infrastructure on learning and time in school in developing countries.

JEL classifications: I21, I25, O15, O18
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I. Introduction and Motivation

Economists and other researchers have shown that education increases workers' productivity, and thus increases their incomes. Education also has many other benefits, such as improved health status and lower crime (Lochner, 2011). Recent research has shown that education increases countries' rates of economic growth (Hanushek and Woessmann, 2015). While these studies offer strong support for investments in education, they shed no light on what types of educational investments are most effective.

Developing country governments generally accept that education provides many benefits, and so they have steadily increased their funding of education. In Latin America, public spending on education as a percent of GDP increased from 3.9 percent in 1995 to 4.4 percent in 2010, and some countries spend even more: Costa Rica, Cuba, and Jamaica all spend more than 6 percent of their GDP on education.[2] International development agencies have also called for greater resources to be devoted to education (OECD, 2013).

This higher spending on education has been accompanied by, and almost certainly has contributed to, higher school enrollment rates. The increases in enrollment over the past two decades, particularly at the secondary level, have been quite dramatic. As seen in Table 1, from 1990 to 2012 primary and secondary enrollment rates have increased in all regions of the developing world, so that by 2012 gross primary enrollment rates were at or above 100 percent in all regions, and gross secondary enrollment rates were well above 50 percent in all regions except Sub-Saharan Africa. In Latin America and the Caribbean, virtually all countries now have gross primary enrollment rates greater than 100 percent, and all have gross secondary enrollment rates well above 60 percent. Similarly, Table 2 shows that primary school completion rates increased in most regions from 1990 to 2012, and were close to 100 percent in all regions except South Asia and Sub-Saharan Africa. Primary school completion rates are close to 100 percent for almost all countries in Latin America and the Caribbean, although a few had lower rates, the lowest two being Guyana (85 percent) and Nicaragua (80 percent).[3]

The above-mentioned increased funding for education in Latin America and elsewhere has often been used to build and staff new schools, especially in areas that had no schools.

[2] World Bank (1998, Table 2.9); World Bank (2012, Table 2.11).
[3] It is possible that Haiti's primary completion rate is even lower, but there are no reliable data from Haiti on most education indicators.

Indeed, several studies have shown that enrollment increases when there is a reduction in the distance to the nearest school. Yet even after the distance to the nearest school has been reduced, there are other ways by which investing in infrastructure could increase enrollment. For example, while access to paved roads has increased in almost all Latin American countries, the percent of roads that are paved is only 23 percent for that region (World Bank, 2012, Table 5.10). This raises the possibility that paving unpaved roads in these countries could increase access to schools even if there are no reductions in the distance to the nearest school.

Another way to increase enrollment is to increase spending on existing schools, either by reducing school fees and other direct costs or by improving school quality, including infrastructure improvements. Regarding the latter, Tables 3 and 4 present data on school infrastructure in Latin America and the Caribbean in 1997 and 2006.[4] Note that the 2006 data are more comprehensive in that they include five additional infrastructure variables and four additional countries. These tables highlight several different characteristics of school infrastructure in Latin America. First, there is a gap between urban and rural schools in both years. For example, no rural schools had computer labs in Brazil in 1997, yet 24 percent of urban schools had them, and while the number increased to 6 percent for rural schools in 2006 the number increased much more (to 64 percent) for urban schools. Second, several types of infrastructure increased over time from 1997 to 2006; for example, averaging over all countries, the share of schools with computer labs increased from 23 percent to 37 percent, and the share with a library increased from 20 percent to 53 percent. Third, there is wide variation in many types of school infrastructure. For example, in 2006, 94 percent of schools in Cuba had access to a computer lab, while Nicaragua and Guatemala were far behind with only nine and ten percent, respectively. Another example is electricity, 100 percent of schools in Uruguay have electricity, but this is true for only 44 percent of Nicaraguan schools and 55 percent of Peruvian schools.

While the improvements over time in school infrastructure are encouraging, in recent years increased attention has been given to school quality and – more specifically – to student learning, and unfortunately there is less evidence of progress. Student performance on the tests

[4] These data are from the Latin American Laboratory for Assessment of the Quality of Education (LLECE), which has implemented two comparative studies that collected data on school infrastructure in the region. PERCE (First Regional Comparative Explanatory Study) was implemented in 1997 and collected data from 1,435 schools in 12 countries on six school infrastructure variables. SERCE (Second Regional Comparative Explanatory Study) was implemented in 2006 and collected data from 2,872 schools in 16 countries on eleven infrastructure variables.

developed by the Programme for International Student Assessment (PISA) is comparable over time starting in the year 2000. Student learning appears to be stagnant or even falling among 15-year-old students in seven Latin American countries, as seen in Table 5. For the time period from 2000 to 2012, two countries show clear upward trends in math scores (Brazil and Chile), while the rest show either mixed or even decreasing trends. For reading scores, the only Latin American country that experienced an increase in scores was Peru. One possible explanation is that expanded enrollment brings in less prepared students, reducing the average score. Yet there are several countries with mixed or declining trends that did not experience large increases in school enrollment, and during this time real expenditures per student increased. For example, in Argentina the gross secondary school enrollment rate has been about 85 percent from 1998 to 2007, and spending per pupil was somewhat higher in 2004-06 than in 1998-2000; yet reading test scores in 2006 were much lower than in 2000. Similarly, Brazil's progress in reading was uneven from 2000 to 2006, yet it experienced only a moderate increase in secondary school enrollment (7-13 percentage points) from 2000 to 2007, and real spending on education steadily increased over that time period.

While policymakers and researchers in both developed and developing countries have interpreted this stagnation in test scores as evidence that progress can be achieved only by changing the way that schools are run, it is still possible that spending that changes basic school and classroom infrastructure characteristics could improve the educational outcomes of students in developing countries. Thus this paper reviews the literature since 1990 on the impact of school infrastructure on students' educational outcomes. More specifically, building on the review conducted by Glewwe et al. (2013), this paper focuses on the impact of infrastructure on educational outcomes, particularly for Latin America. Given the different focus of this study, and its extension of the time horizon from 2010 to 2012, there are 16 studies included in this paper that were not included in Glewwe et al. (2013). The inclusion of these other studies and the focus on classroom and school level infrastructure, as well as utilities, is a distinguishing feature of the present study.

This paper examines both the economics literature and the education literature published from 1990 to 2012 to assess the extent to which school infrastructure characteristics have a causal impact on student learning and enrollment. School infrastructure includes classroom level infrastructure and other classroom characteristics (natural light, temperature, acoustics), as well

as school level infrastructure, which includes school utilities (availability of electricity, potable water, and the condition of the building) and other features of the school (such as the existence of a library, a computer lab, or science labs). The definition of infrastructure used in this study excludes textbooks, other pedagogical materials, and information and communications technology (ICT).[5]

The rest of the paper is organized as follows. The next section describes the methodology used to identify the studies to include in this review. In the following section the results of this literature review for developing and developed countries are presented, with a special focus on Latin American countries. The paper then summarizes the results and draws several conclusions.

II. Methodology for Reviewing the Literature

This paper reviews the literature from 1990 to 2012 that has estimated the impact of school infrastructure on student learning and time in school in both developing and developed countries. It focuses on papers published in peer-reviewed journals between 1990 and 2012, but also includes working papers from 2008 to 2012. Studies published before 1990 are excluded. The review includes studies of pre-primary, primary, secondary, and vocational education, but excludes tertiary level education. The outcomes of interest include test scores in different subjects, enrollment, dropping out, years of schooling, and daily attendance.[6] This review of the literature focuses on the impact of school infrastructure variables, which include: the condition of the walls, floors, and roof; instructional materials in the classroom (such as flip charts and blackboards, but excluding textbooks); the availability of electricity, water, and toilets; and the availability of laboratories (science and computer), libraries, desks, and blackboards.[7]

Before explaining how the literature review was conducted, it is important to clarify which relationships that literature attempts to estimate, and to briefly discuss problems that arise when attempting to estimate these relationships.[8]

[5] The physical presence of a computer was included in this study, but software or programs related to information and communications technology were excluded.
[6] Unlike previous studies, this paper searched for impacts on other educational outcomes, such as school bullying, cheating, conflict, crime, security and delinquency. However, we found no studies on these outcomes that met our minimum criteria for quality.
[7] The complete list of school infrastructure variables is given in Appendix I.
[8] The following paragraphs summarize a more detailed exposition given in Glewwe et al. (2013).

To begin, assume that children's parents maximize, subject to constraints, a (lifecycle) utility function. The main arguments in the utility function are consumption of goods and services (including leisure) at different points in time, and each child's years of schooling and learning. The constraints faced are the production function for learning, the impacts of years of schooling and of skills obtained on the future labor incomes of children, a life-cycle budget constraint, and perhaps some credit constraints or an agricultural production function. The production function for learning is a structural relationship that can be depicted as:

$$A = a(S, \boldsymbol{Q}, \boldsymbol{C}, \boldsymbol{H}, \boldsymbol{I}) \qquad (1)$$

where A is skills learned (*achievement*), S is years of schooling, **Q** is a vector of school and teacher characteristics (inputs that raise school *quality*), which include school infrastructure variables, **C** is a vector of child characteristics (including "innate ability"), **H** is a vector of household characteristics, and **I** is a vector of school inputs under the control of parents, such as children's daily attendance and purchases of textbooks and other school supplies.

For a given school, parents choose S and **I** (subject to the above-mentioned constraints) to maximize household utility. Both years of schooling S and schooling inputs **I** are general functions of **Q**, **C** and **H**, as well as prices related to schooling (such as tuition, other fees, and prices of textbooks and uniforms), which are also exogenous and can be denoted by the vector **P**. Inserting these equations for S and **I** into (1) gives a reduced form equation for (A):

$$A = h(\boldsymbol{Q}, \boldsymbol{C}, \boldsymbol{H}, \boldsymbol{P}) \qquad (2)$$

This reduced form equation is a causal relationship, but it is not a textbook production function because it reflects household preferences and includes prices among its arguments.

Turning to the impact of infrastructure and other school quality variables (**Q**) on student learning, there are two distinct relationships. To see this, consider a change in one element of **Q**, call it Q_i. Equation (1) shows how changes in Q_i affect A when all other explanatory variable are held constant, and thus provides the *partial* derivative of A with respect to Q_i. In contrast, equation (2) provides the *total* derivative of A with respect to Q_i because it allows for changes in S and **I** in response to the change in Q_i. For example, parents may respond to higher school quality by increasing their provision of educational inputs such as textbooks. Alternatively, if they consider higher school quality a substitute for those inputs, they may decrease those inputs.

Many studies attempt to estimate the impact of school and teacher characteristics, including school infrastructure, on enrollment and learning, yet these attempts face a number of serious estimation challenges. The most common generic concerns are omitted variable bias, sample selection, endogenous program placement, and measurement errors. Turning to the first concern, if major inputs to achievement are omitted from the estimation of equation (1), they may be correlated with the included variables, which results in biased estimates of the impacts of the included variables. School quality could also be correlated with unobserved variables if governments improve schools that have unobserved education problems (Pitt, Rosenzweig, and Gibbons, 1993). Governments may also raise school quality in areas with good education outcomes, if those areas have political influence (World Bank, 2001). The former causes underestimation of school quality variables' impacts on learning, while the latter causes overestimation. Finally, measurement error – a ubiquitous problem that can be particularly severe in developing countries – can bias estimates, often pushing estimates toward zero and making factors appear to be insignificant.

Considerable effort has gone into how to deal with these problems. Most significant in recent decades has been the implementation of randomized experiments that is the use of randomized control trials (RCTs). But other methods such as regression discontinuity (RD) designs and panel data methods have also been pursued to achieve the same goal. Note that, in general, RCTs and RD methods estimate the impacts as given in equation (2), rather than the production function of equation (1). Other methods often attempt to estimate equation (1). Unfortunately, many studies do not clarify which of the two types of relationships they are attempting to estimate, and this review will not attempt to make this distinction.

The remainder of this section describes how the very large literature available was searched and categorized by quality of analysis. The first step was to classify studies into three categories: medium quality, high quality, and randomized control trials (RCTs). Medium quality papers are those studies whose estimation strategy includes ordinary least squares (OLS), as well as some studies that used hierarchical linear model (HLM) methods. The high quality papers use other, more sophisticated estimation methods, such as instrumental variables (IV), regression discontinuity, matching methods, differences in differences, or panel data methods such as fixed effects regression. All RCTs were classified as a separate "very high quality" method because this method minimizes the estimation problems discussed above. While this paper presents

evidence for all developing countries, a particular focus was placed on Latin American countries. For Latin America, the review includes all studies that met the medium quality requirement. When all developing countries are considered, including Latin American countries, results are presented for all studies, then only for high quality studies (which include RCTs, and then only for RCTs. For studies conducted in developed countries, only those that met the high quality criteria, including RCTs, were included.

In searching for relevant studies, we searched for papers that included a list of keywords that included "education", a list of 86 infrastructure inputs, and a list of 35 educational outcomes. For a study to appear in our search, it needed to have the word "education", at least one of the infrastructure inputs, and at least one of the educational outcomes from this list of keywords. This list of keywords was created from analyzing all the keywords in the Education Resources Information Center (ERIC) to choose those that are relevant for the scope of this study.[9] In order to further refine the search, a list of developing country names was included. These developing countries came from the International Monetary Fund's list of emerging and developing countries. The authors searched both the educational and the economic academic literatures (using ERIC and EconLit, respectively) when searching for peer-reviewed articles.

Table 6 provides a summary of the search process and the number of articles reviewed in each phase. The initial search of studies on developing countries yielded nearly 9,000 articles. These articles were reviewed individually by two of the authors, keeping the articles that appeared to be relevant to the study based on information found in the abstract. In the search for developing country articles, papers that analyzed developed countries or tertiary education, as well as papers that focused on information and communications technologies (ICTs), were excluded.[10] Based on this initial review, 382 papers were retained for the next phase of the selection process.

After eliminating papers whose estimation strategies were not of medium or high quality, which was based on an initial review of the paper's methodology section, only 82 papers remained. In addition, 27 studies from the Glewwe et al. (2013) meta-analysis study were added

[9] See Appendices I and II.
[10] This was done because this paper focuses on the presence of physical infrastructure, such as computer hardware, but not software or programs that are used as instructional or pedagogical materials.

to the review.[11] To include more recent studies, 13 working papers that appeared from 2008 to 2012 in prominent working paper series were included. These included the Inter-American Development Bank Working Papers, Abdul Latif Jameel Poverty Action Lab (J-PAL) working papers, World Bank Policy Research working papers, and National Bureau of Economic Research (NBER) working papers.

Two of the authors reviewed the full text of each of these 122 papers; this step revealed further analytical weaknesses or lack of relevance so that only 58 papers were retained. These 58 were then reviewed for the adequacy of their basic covariates; to be retained, a study was required to include at least one school variable, at least one family variable, and at least one teacher variable (or another school variable). Examples of school variables are the availability of electricity and the presence of adequate desks in the classroom. Examples of family variables include household income, parental education levels, and family size. A teacher level variable could include teacher salary level, teacher education or experience, or the teacher's race. After dropping papers that did not meet these criteria, the final sample of both medium quality and high quality studies consisted of 39 papers on developing countries. These papers were then divided into the three categories: all 39 met the medium quality criteria, 19 met the higher quality criteria (used a more sophisticated estimation method), and four were RCTs.

For developed country articles, the same search process was used, but the studies retained were limited to those that used the above mentioned "high quality" statistical methods. This search yielded approximately 350 articles from the educational academic literature (ERIC database) and 150 articles from the economics literature (EconLit database). These articles were reviewed in detail and, based on their relevance and the rigor of their methodology, only four papers were included in this review.

Using the same criteria as for developing countries (medium quality papers), the authors also checked 23 well regarded Latin American and Caribbean research institutions for working paper series from 1990-2012. These included working papers written in English, Spanish or Portuguese. From this additional search, the authors added three papers to the 13 Latin American studies discovered during the initial search of the economic and educational academic literatures.

[11] These studies were dropped from the initial search because some of the infrastructural variables were used as controls and the abstracts did not reveal the paper to be relevant in the initial search. They were not dropped from Glewwe et al. (2013) because of the wider scope of that study.

III. Results

This section presents the findings of this literature. Table 7 summarizes the number of studies available, classified by quality of study and type of infrastructure. The three types of infrastructure are defined as follows. First, classroom level infrastructure refers to furniture, such as desks, as well as basic materials such as blackboards, flip-charts, chalk, and other types of classroom infrastructure such as a classroom library. Second, school level infrastructure includes general school building characteristics, such as the type and condition of the walls, floor and roof, and the presence of a school library. One type of school level infrastructure, school amenities, refers to general school-level indices of items such as walls to separate classrooms, equipment available at the school, the number of specialized rooms (such as libraries or science labs), the reliability of electricity, a compilation of available writing materials (pens, pencils, paper, notebooks, a complete set of required text books, dictionaries), ventilated classrooms, noise level, or computers for administrative use. Third, utilities refer to water, electricity, and sanitation facilities (such as toilets) within the school. For each of these types of infrastructure, results are presented of the impacts both on student test scores and on students' time in school. In addition to the results for developing countries, findings from developed country studies are briefly discussed. Finally, each section highlights findings from studies on Latin American countries, based on sixteen studies that examined the impact of school infrastructure on educational outcomes in Latin America and the Caribbean.

Within each type of infrastructure, the studies from developing countries are classified by analytical rigor into three types: medium quality, high quality and RCTs. RCTs are arguably the best methodology for analyzing the impact of school infrastructure on educational outcomes. Unfortunately, very few RCTs have examined the impacts of different types of school infrastructure on student outcomes.

A. Classroom Level Infrastructure

Table 8 summarizes the findings of 11 studies that examined the impact of classroom infrastructure on student learning as measured by test scores, and Table 9 summarizes the findings from six studies of the impact of classroom infrastructure on time in school variables

(enrollment, attendance, years of schooling and dropping out).[12] The next panel in each of these tables shows findings from the high quality studies, followed by RCTs, and studies specific to Latin America and the Caribbean.

Classroom Furniture (desks, tables, chairs)

Four studies estimated the impact of the availability of classroom furniture (desks, tables, chairs) on test scores in developing countries, and the results are somewhat ambiguous. Of the eight estimates in these four studies, five are statistically insignificant. Of the three statistically significant estimates, two are negative and one is positive (all at the elementary or secondary level). Of the four studies, one finds significantly negative results of classroom furniture on the reading and math scores of grade 5 students in urban and rural areas of Vietnam (Hungi, 2008), one study finds a significant positive effect in urban and rural areas of Jamaica on primary school students' reading test scores (Glewwe et al., 1995), and the other two find no significant effects.

When the evidence is limited to high quality studies conducted in developing countries, there are only two: the study of urban and rural areas of Ghana by Glewwe and Jacoby (1994), and the study of rural areas in Pakistan by Khan and Kiefer (2007). These two high quality studies provide four estimates of the impact of classroom furniture on student learning, all of which are statistically insignificant. Thus there is no evidence from high quality studies that classroom furniture increases students' test scores. Note finally that there are no RCT estimates of the impact of classroom furniture on learning in developing countries.

The Jamaica study by Glewwe et al. (1995) was the only one of the four studies that was conducted in Latin America or the Caribbean; it yielded only one significant result, showing a positive impact of classroom furniture on test scores. Since this result is from a single paper, there is insufficient evidence for drawing general conclusions on the impact of classroom infrastructure on test scores in Latin America.

Turning to the time in school estimates in Table 9, only one study examined the impact of the availability of furniture (desks, tables, chairs) on time in school variables: Glewwe and Jacoby (1994). This high quality study found no significant impacts. There are no RCT studies

[12] While it may seem that there are 16 (4 + 8 + 3 + 1) studies of classroom infrastructure in the top four lines of Table 8, rather than 11, there are only 11; some 11 studies appear in more than one of those lines because they are regression analyses with multiple explanatory variables.

in developing countries that have examined the impact on students' time in school of classroom furniture. Unfortunately, there are no studies analyzing the impacts of any classroom infrastructure variables on time in school for Latin-American countries.

As shown in Table 14, one developed country study analyzed the impact of classroom furniture on student learning in the United States. Harter (1999) presents six estimates, all insignificant, on reading and math test scores. There are no high quality studies that estimate the impact of other types of classroom level infrastructure variables (class library, blackboards, or the quality of roofs, walls, or floors) in developed countries.

Blackboards, Flipcharts, or Chalk

In contrast, the evidence on the availability of blackboards, flipcharts or chalk in the classroom is more extensive: 48 estimates from 8 studies. When medium quality studies are included, this type of classroom infrastructure often appears to increase students' test scores at both the elementary and secondary school levels. More specifically, eight of the nine statistically significant results are positive. Most of these significant results are from studies conducted in African countries: Glewwe and Jacoby (1994) in Ghana, Glick et al. (2011) in urban and rural areas of Madagascar, and Lee (2005) for urban and rural areas of 14 sub-Saharan countries.

However, when the evidence is limited to the high quality studies, little or no support is found for this type of infrastructure. Of the 15 estimates of the impact of the availability of blackboards, flipcharts or chalk in the classroom on students' test scores in elementary and secondary schools, 13 are statistically insignificant, one is significantly negative, and one is significantly positive. The one positive result is for math test scores in Ghana at the secondary level (Glewwe and Jacoby, 1994). The only negative significant result, for dictation test scores at the primary level in urban and rural areas of Indonesia, is from Suryadarma et al. (2006).

There is only one paper that used a randomized control trial to examine the impact of classroom infrastructure on test scores: Glewwe et al. (2004). The paper reports a positive but insignificant impact of flipcharts on students' test scores in a rural area of Kenya. Overall, the evidence suggests that blackboards and/or flip charts have little or no effect on student learning.

Regarding time in school outcomes, Table 9 shows that there is weak evidence that blackboards or flipcharts in the classroom have a positive impact. Of the 26 estimates of these

relationships from two studies, only two are significant, but both are positive.[13] More specifically, both studies report one specification with a significant impact of blackboards (as well as many insignificant specifications). These two studies examined attendance in rural India (Afridi, 2011) and on grade attainment in urban and rural areas of Ghana (Glewwe and Jacoby, 1994).

Condition of Roofs, Walls, and Floors

There is some evidence that the condition of classroom roofs, walls, and floors increases student learning as measured by test scores. While the three studies yield three negative and three positive estimates, two of the three positive estimates are statistically significant (both are from Glewwe and Jacoby, 1994), while none of the negative estimates is statistically significant. When the evidence is limited to high quality studies, the only study (Glewwe and Jacoby, 1994) provides consistently positive evidence: both estimates, which pertain to the condition of schools roofs, are positive and significant, but this is based on only a single study.

Four studies examined the impact of the condition of roofs, walls and floors on time in school; only four of the 30 estimates are statistically significant. Of these 30 estimates, one is significantly positive (Brown and Park, 2002) and three are significantly negative (Glewwe and Jacoby, 1994; Zhao and Glewwe, 2010). The Brown and Park and Zhao and Glewwe studies both examine students in rural areas of China. Overall, the results generally suggest no systematic impact of the condition of roofs, walls, and floors on students' time in school. This is also the case when the evidence is limited to high quality studies. Similarly, no conclusions can be drawn regarding the impact of the condition of walls or floors in the classroom, since no high quality studies examined these conditions. However, one study has two significantly positive estimates of the impact of roofs on student learning (Glewwe and Jacoby, 1994). Note that there are no RCT studies on this type of school infrastructure.

Classroom Library

[13] Afridi (2011) estimated the impact on attendance rates for children in India in grades 1-5 separately for each grade and separately by gender, leading to the large number of estimates.

Finally, there is no evidence that the availability of a classroom library increases student learning. The sole study is Zhao and Glewwe (2010), which is a high quality study but not an RCT. They found no significant results. There are no studies of the impact of classroom libraries on students' time in school.

B. School level Infrastructure

Consider next the impact of school level infrastructure, such as libraries, science laboratories, computers, and even the construction of new schools, on students' educational outcomes. Table 10 presents the findings for test scores, and Table 11 presents the results for time in school.

Overall School Infrastructure

Sixty-one estimates from 14 studies estimate the impact of overall school infrastructure on test scores; of these, 26 estimates are insignificant, 5 are significantly negative, and 30 are significantly positive. The definition of overall school infrastructure varies by study, but can include: the overall condition of the school; the average condition of the classrooms based on space, lighting, noise, and desks (Marshall, 2009); the proportion of usable rooms; an index of school quality (Anderson, 2000); physical facilities and teaching materials (Aslam and Siddiqui, 2003); the reliability of electricity; and the number of specialized instructional rooms (Engin-Demir, 2009). Overall, the evidence indicates that overall school infrastructure increases student learning outcomes.

Four high quality studies examined the impact of overall school infrastructure on test scores; six of the fourteen estimates are insignificant. Of the eight statistically significant estimates, six are positive (Fehrler et al., 2009, and Yamauchi and Liu, 2013) and two are negative (Glewwe and Jacoby, 1994, and Suryadarma et al., 2006), which suggests a positive impact of school infrastructure on student learning. Note that none of the four high quality studies is an RCT.

Turning to Latin America, there were 31 estimates from five studies of the impact of overall school infrastructure on test scores: 27 are positive, of which 21 are significant, and 4 are negative, of which 2 are significant. Most of these results come from the Second Regional

Comparative and Explanatory Study (SERCE) which covers 16 countries across Latin America and the Caribbean (Treviño et al., 2010). Thus, the evidence indicates that general school level infrastructure in Latin America seems to increase student learning.

Finally, consider the impact of overall school infrastructure on time in school, which is shown in the first line of Table 11. Twelve estimates from four studies examine these impacts; of these, eleven are insignificant and one is significantly positive. Thus there is at most only weak evidence that the general condition of school infrastructure increases students' time in school. For overall school infrastructure there are only two high quality studies that examined impacts on time in school (Glewwe and Jacoby, 1994; Lloyd et al., 2003). Seven of the eight estimates were statistically insignificant, and the one that was significant was positive. This offers only weak support for a general impact of school infrastructure on time in school.

School Libraries

Seven studies provide 26 estimates of the impact of a school library on test scores. Of these 26 estimates, 17 are insignificant, two are significantly negative, and seven are significantly positive, which provides some evidence that school libraries increase student learning. Five of these seven studies are of high quality, providing 20 estimates of the impact of a school library on test scores. Of these, 15 are statistically insignificant, four were significantly positive (Fehrler et al., 2009, Glewwe and Jacoby, 1994, and Sprietsma, 2012), and one was significantly negative (Suryadarma et al., 2006), providing some, but rather weak, evidence that a school library increases students' learning. Each of the four studies with statistically significant results included both urban and rural areas. One of these, Borkum, He and Linden (2013), is an RCT study that estimated the impact of school libraries on test scores in India; all four estimates are negative and statistically insignificant.

One developed country study analyzed the impact of library books per student on student learning in United States secondary schools: Konstantopoulos and Borman (2011). As seen in Table 14, of the six estimates, four are insignificant and two have significantly positive impacts. Thus there is some evidence that library books increase student learning in secondary schools in developed countries.

Turn next to the impact of the presence of a school library on test scores in Latin America. Of six estimates from two studies, three are positive and statistically significant, two are negative but insignificant, and one is significantly negative. These findings are from two studies, an analysis of rural primary schools in Colombia by McEwan (1998) and a paper on urban and rural secondary schools in Brazil by Sprietsma (2012). These studies suggest that school libraries in Latin America can increase student learning at both the primary and secondary levels.

Finally, three studies, all of which are high quality studies, estimate the impact of a school library on time in school. As seen in Table 11, the results are somewhat ambiguous. Of the 15 estimates, 10 are insignificant, one is significantly negative and four are significantly positive (all four of which are from the same study). One RCT analyzed the impact of a school library on time in school, that of Borkum, He and Linden (2013), who collected data from urban and rural schools in India; yet their results are disappointing since the estimated impact is statistically insignificant.

Computers

There are many proponents of the benefits of providing computers and other types of information technology hardware to schools. Six studies analyzed the impact of computers on student test scores; 56 estimates are insignificant, 3 are significantly negative, and 20 are significantly positive, which suggests that, in many cases, computers can increase student learning. Four of these studies were high quality (Banerjee et al., 2007; Barrera-Osorio and Linden, 2009; Fehrler, 2009; and Sprietsma, 2012). Fifty-one of the 72 estimates from three different high quality studies were insignificant, three were significantly negative and 18 were significantly positive. While these results indicate that computers can increase student learning, the 18 significantly positive estimates are from only three different studies, and the three significantly negative estimates are from two different studies, so giving equal weight to each study yields only weak support for computers. Limiting the evidence to the two RCT studies, Banerjee et al. (2007) and Barrera-Osorio and Linden (2009) yields results which are very similar to those of the four high quality studies, since most of the estimates are from these two RCT studies.

Two studies in developed countries estimated the impact of computers on student learning. Kotte et al. (2005) found a significantly negative impact (of the ratio of computers per student) on reading scores in Germany. On the other hand, Carneiro (2008) found three insignificant results for the impact of computers (number of computers divided by school size) on various test scores in secondary schools in Portugal. Overall, these two studies from developed countries yield no support for a positive impact of computers on student learning.

There are 72 estimates from studies of Latin American countries that attempt to measure the impact of computers on student learning.[14] Of these estimates, 38 are from a randomized control trial in Colombia that showed positive, but mostly insignificant, impacts of computers on educational outcomes (Barrera-Osorio and Linden, 2009). Most of the remaining estimates come from the SERCE study (Treviño et al., 2010). Of these 72 estimates, 31 from three different studies are significantly positive. Only two, from a single study, are significantly negative. Thus the results suggest a positive impact of the availability of computers in schools on students test scores for Latin America.

Only one study, Barrera-Osorio and Linden (2009), analyzed the impact of computers on time in school. As seen in Table 11, that study yielded one significantly negative estimate and four insignificant estimates (of which two were negative and two were positive); thus there is no evidence that computers increase students' time in school.

School Amenities

Twenty-four estimates from seven studies analyze the impact of school amenities on students' test scores. School amenities range from an index of writing and reading materials, such as pens, pencils, paper, notebooks, a complete set of required textbooks and dictionaries (Glewwe et al., 1995), to computers for administrative use (Lockheed et al., 2010). As seen in Table 10, ten estimates are insignificant, seven are significantly negative, and seven are significantly positive, and thus the findings are ambiguous.

Limiting the evidence to four high quality studies yields 15 estimates of the impact of school amenities on test scores. Seven of these are insignificant, three (from a study of urban

[14] These estimates include estimates from a working paper by Treviño et al. (2010) that are not included in the "all studies", "high quality studies" and "RCTs" results because that working paper is not one of the working paper series selected for the review (see Section II).

and rural schools in Indonesia by Suryadarma et al., 2006) are significantly negative, and five (from a study of urban and rural schools in South Africa by Van der Berg, 2008) are significantly positive. Thus the impact of school amenities on test scores is ambiguous even for high quality studies. Note that there are no estimates from RCT studies.

Four studies from Latin America have examined the impact of school amenities, which include ventilation, lighting and noise, on test scores. Of the 11 estimates, five are insignificant, four are significantly positive, and two are significantly negative, which provides at best only weak support that amenities matter.

As seen in Table 11, only one study analyzed the impact of school amenities on time in school. The findings of the study's two estimates are at best only suggestive given that there is only one study: both are positive, but one is significant while the other is not. Note that this was a high quality study, but not an RCT, and that it was from a Latin American country (Brazil).

Science Laboratories

Only one study, which is a high quality study, analyzed the impact of science laboratories on students' test scores, and it finds inconclusive evidence. The study of urban and rural schools in Brazil by Sprietsma (2012) yielded two estimates, one of which is significantly negative and the other of which is significantly positive, and thus these results of the impact of science laboratories on test scores are ambiguous. Note that this study is on a Latin American country.

Konstantopoulos and Borman (2011) also analyzed the impact of science laboratory facilities on learning, but in a developed country setting: U.S. secondary schools. As seen in Table 14, of the six estimates, three are insignificant and three are significantly positive, which provides some evidence that the availability of science laboratory facilities increases student learning in developed countries.

A single study provided 12 estimates from rural schools in China of the impact of science laboratories on time in school (Zhao and Glewwe, 2010). Aas seen in Table 11, these estimates suggest a positive effect. More specifically, of the twelve estimates, six are insignificant and the other six are significantly positive.

Creation of New Schools

Finally, four estimates from a single high quality study show that the creation of a new school has a significantly positive impact on student learning. As seen in Table 10, all four estimates are significantly positive, indicating that the creation of a new school increases test scores, perhaps by reducing students' travel time, which frees up more time for studying (Yamauchi and Liu, 2013). Note that this study is from urban and rural areas of the Philippines, and thus there is no evidence from Latin America.

Two studies, both of which are high quality, have analyzed the impact of the creation of a new school on time in school. As seen in Table 11, they provide some evidence that new schools increase time in school. Of the 16 estimates, five are insignificant, two are significantly negative, and nine are significantly positive. While this evidence seems strong, when equal weight is given to each study, the results are more ambiguous; both studies find significantly positive and significantly negative effects. Note that both of these studies are on Latin American countries, one on Guatemala and one on Argentina, and both focus on the availability of pre-primary education facilities.

C. Utilities

The third and last type of school infrastructure examined in this paper is utilities, which includes electricity, drinking water, and toilet facilities. Table 12 summarizes the findings of the impacts of utilities on test scores, and Table 13 does the same for time in school.

Electricity

Seven studies provide 28 estimates of the impact of the availability of electricity on students' test scores at the primary and secondary school level. As seen in Table 12, of these estimates 18 are insignificant, nine (from three separate studies: Bacalod and Tobias, 2006; McEwan, 1998; and Psacharopoulos et al., 1993) are significantly positive, and one is significantly negative (Psacharopoulos et al., 1993). Overall, the evidence indicates that, in many settings, provision of electricity could increase student learning. However, when only high quality studies are examined, there is no evidence of an impact of electricity on test scores; all 14 estimates from three different studies (Fehrler et al., 2009; Glewwe and Jacoby, 1994; and Suryadarma et al., 2006) are statistically insignificant, of which five are negative and nine are

positive. Note that there are no RCT studies of the impact of electricity on students' educational outcomes.

Three papers from Latin America estimated the impact of electricity on test scores. As seen in Table 12, of the 13 estimates, eight estimates from two different studies (McEwan, 1998, and Psacharopoulos, 1993, both of which focus on rural areas) are significantly positive, which suggests that provision of electricity in Latin American increases student learning. Note, however, that none of these three papers is a high quality study. Finally, one Latin American study analyzed the impact of an index of utilities, which includes water, electricity, and a telephone connection. There were 16 estimates from 16 countries, all of which were significantly positive. This suggests that utilities may have a strong impact on student learning in Latin America, but caution is in order because this is based on a single study.

Only one study examined the impact of the availability of electricity on time in school. As seen in Table 13, and all four estimates were statistically insignificant (Glewwe and Jacoby, 1994).

Drinking Water Facilities

While adequate drinking water facilities would seem to be desirable for any school, there is no evidence that such facilities promote student learning. In particular, Table 12 shows that all ten estimates from the three studies of the impact of the availability of drinking water facilities are statistically insignificant. Similarly, the eight estimates from two high quality studies of the impact of drinking water are all statistically insignificant (Fehrler et al., 2009; Glewwe and Jacoby, 1994). There are no RCT studies of the impact of drinking water facilities on students' educational outcomes.

Turning to Latin America, there is one paper, with two estimates, that analyzed the impact of drinking water facilities on test scores. As seen in Table 12, that paper reaches the same conclusion: both estimates were statistically insignificant, so there is no evidence from Latin American countries that the provision of drinking water facilities increases student learning.

Finally, consider the impact of drinking water facilities on students' time in school. Two studies, both of which are of high quality, provide 30 estimates of the impact of the availability

of drinking water facilities on time in school. Of these estimates, 27 were statistically insignificant and only three had significantly positive impacts on time in school, which suggests at best a weak impact.

Toilet Facilities

The last utility variable to consider is sanitation, and more specifically toilet facilities. There are 33 estimates from four studies that examine the impact of the availability of toilets or separate latrines for boys and girls on student learning. These estimates suggest that having access to adequate sanitation facilities increases students' test scores at both the primary and secondary levels. More specifically, of the 33 estimates 11 are insignificantly negative and 6 are insignificantly positive, while 16 estimates from three different studies are significantly positive and none is significantly negative. Yet when the evidence is limited to the two high quality studies, there is only modest evidence that access to adequate sanitation facilities increases students' test scores; while nine of the ten estimates from two high quality studies are positive, only two estimates, both from the study of Indonesia by Suryadarma et al. (2006), are significantly positive. Note that there are no RCT studies of the impact of toilet facilities on students' educational outcomes.

One Latin American study examined the impact of sanitation facilities on educational outcomes, both test scores and time in school. The study tracked students in the city of Puno in Peru and showed that the availability of sanitation facilities led to increased reading comprehension (Cueto et al., 2010). More specifically, both of the two estimates in this study were positive, of which one was significantly positive. The same study provides estimates on time in school; the evidence provides no support for this intervention, as there were two insignificantly negative estimates.

Finally, one study provides 26 estimates of the impact of the availability of toilet facilities on school attendance, at the elementary school level.[15] Of these 22 were statistically insignificant, one was significantly negative and the other three were significantly positive; all of the estimates come from Afridi (2011) and they provide some, but rather weak, evidence that toilet facilities increase time in school for girls.

[15] The Cueto et al. (2010) study in the previous paragraph is excluded because it is a working paper this is not in our set of high quality working papers (see Section II).

IV. Conclusion

This paper has reviewed the results from 39 studies on the impact of school infrastructure on student outcomes. The results from this literature, which span 23 years from 1990 to 2012, are summarized in the Tables 8-14. Overall, the evidence base is not particularly strong. Focusing on the 19 high quality studies from all developing countries, there is limited evidence that having roofs, walls, and floors in good condition improves student learning, but no other classroom level variables have clear effects. Turning to school level infrastructure, there is some evidence that school libraries and the creation of new schools (which make schools more accessible) leads to improved learning. The evidence on computers appears strong when each estimate is given equal weight, but is much weaker when each study is given equal weight. Finally, with the possible exception of toilets there is no evidence that utilities affect student learning.

The evidence on the impact of infrastructure variables on time in school, also tends to be inconclusive. There is weak evidence of a positive impact of blackboards and related items, and stronger evidence of the impact of school libraries. There is also evidence of positive impacts of science laboratories, the creation of new schools, and drinking water facilities.

When the evidence is limited to 16 medium and high quality studies from Latin America, the evidence is also mostly inconclusive for both student learning and time in school. At the classroom level, there is evidence from a single study of urban and rural areas of Jamaica that desks, tables, and chairs matter for student learning. Turning to school level infrastructure, three studies have found positive impacts of overall indices of school infrastructure for both student learning and time in school, but this result is not very useful since one would like to know which components of the index are most important. There is some evidence, from rural areas of Colombia and from urban and rural areas of Brazil, that libraries have a positive effect on learning, and even stronger evidence that computers have an effect. There is suggestive evidence that school amenities also have an effect on both learning and time in school, but these can take many forms and so this result is not particularly useful. As expected, the construction of new schools also increases time in school. Finally, there is some evidence that electricity has positive impacts on learning, and weak evidence that sanitation may as well.

Ideally, for the few interventions that appear to be effective one would like to know their costs, so that one could undertake cost-effectiveness comparisons or, more ambitiously, cost-benefit analysis. Unfortunately, very few studies provide information on the costs of the interventions, so this was not possible for this review; future studies should report those costs.

Perhaps the main conclusion of this study is that more high quality research is needed on the impact of infrastructure on learning and time in school in developing countries. This raises the question of why there has been relatively little research on the impact of school infrastructure on education outcomes. While somewhat speculative, the following explanations seem plausible. First, in developed countries there is little research on basic infrastructure, such as electricity and water, because almost all schools have them and thus there is very little variation across schools that can be used to estimate an effect. Second, in most studies infrastructure is used only as a control variable in regression analysis since the main interest is in other variables, and thus there is little discussion of the impacts of infrastructure variables even when they are included in the analysis. Third, many new studies on education in developing countries employ randomized control trials (RCTs), and it is often very costly, and more contentious, to randomly assign some schools to receive infrastructure improvements while others do not receive them (or receive them at a much later date). Fourth, many infrastructure improvements (such as electricity, potable water, and adequate sanitation) are assumed to be desirable, perhaps even if they may not have large impacts on educational outcomes, and so there is little "demand" for research on this topic. Finally, the quality of many types of school infrastructure is likely to deteriorate slowly over time, and so it may be difficult to measure the decrease in quality, which will generate "noisy" data and thus statistically insignificant estimates.

While there is a dearth of high quality studies on infrastructure in Latin America and in other developing countries, research funds are scarce and so agencies that fund research need to carefully consider which types of infrastructure investments should receive the highest priority for future research funding. Some types of infrastructure, such as electricity and running water, may be considered as necessary for virtually all schools, and so there is little reason to conduct research on them. Very expensive improvements in infrastructure may also be a low priority because they would have to have very large effects to be cost-effective investments. Any types of investments that are being heavily funded, such as the use of computers and other information technology devices, should be a high priority given the large investments being made in those

types of infrastructure improvements. Such a priority setting exercise would seem to be necessary to ensure that future research provides valuable information for education policy decisions in Latin America, and more generally in all developing countries.

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Table 1

PRIMARY AND SECONDARY GROSS ENROLLMENT RATES: 1990-2012

	Primary			Secondary		
	1990	2000	2012	1990	2000	2012
By world region						
Latin America and the Caribbean	116	119	109	60	82	88
East Asia and Pacific	120	105	118	39	57	83
Middle East and North Africa	95	99	110	56	68	78
South Asia	87	92	111	36	44	63
Sub-Saharan Africa	72	82	100	23	26	41
Latin America and the Caribbean						
Argentina	106	114	118[B]	71	87	92[B]
Bahamas	98	97	108	86	78	93[A]
Barbados	116	102	105[B]	86	105	105[B]
Belize	113	120	121	61	68	84
Bolivia	104	112	94[B]		78	77[B]
Brazil	141					
Chile	105	100	101	78	82	89
Colombia	105	119	107	52	72	93
Costa Rica	102	110	105	43	61	104
Dominican Republic	100	113	103		59	76
Ecuador	125	113	114	59	59	87
El Salvador	94	104	113	38	54	69
Guatemala	77	104	114[B]	23	38	65[B]
Guyana	105	104	75		97	101
Haiti	75					
Honduras	107	107	109	33		73
Jamaica	104	97		70	87	89[B]
Mexico	111	106	105[A]	53	70	86
Nicaragua	87	101	117[A]	37	53	69
Panama	100	105	100	59	65	84
Paraguay	104	120	95[B]	31	61	70[B]
Peru	119	122	100	67	85	90
Suriname	117	118	114[B]	56	73	85[B]
Trinidad and Tobago	96	105	106[A]	83		
Uruguay	109	109	112	81	98	90
Venezuela	105	101	102	56	60	85

A. Latest available data was for 2010.

B. Latest available data was for 2011.

Source: World Development Indicators, World Bank.

Table 2

PRIMARY SCHOOL COMPLETION RATES

	Primary	
	1990	**2012**
By world region		
Latin America and the Caribbean	82	95
East Asia and Pacific	99	105[A]
Middle East and North Africa	76	95
South Asia	64	91
Sub-Saharan Africa	54	70
Latin America and the Caribbean		
Argentina		109[B]
Bahamas		93[A]
Barbados		104[B]
Belize		116
Bolivia	70	92[B]
Brazil		
Chile		97
Colombia	74	105
Costa Rica	75	95
Dominican Republic		90
Ecuador		111
El Salvador	63	101
Guatemala		88[B]
Guyana		85
Haiti		
Honduras	64	100
Jamaica	97	
Mexico	87	99
Nicaragua	39	80[A]
Panama		98
Paraguay	65	86[B]
Peru		91
Suriname		88[B]
Trinidad and Tobago	100	95[A]
Uruguay	95	104[A]
Venezuela	78	96

A. Latest available data was for 2010.
B. Latest available data was for 2011.

Source: World Development Indicators, World Bank.

Table 3

SCHOOL INFRASTRUCTURE IN LATIN AMERICA - 1997
(Share of Schools with different school facilities)

	Sports facilities	Science Lab	Computer Lab	Dining Hall	Nurse Station	Library
All Countries	0.68	0.17	0.23	0.26	0.10	0.20
Argentina	0.65	0.21	0.33	0.18	0.05	-
Bolivia	0.70	0.24	0.24	0.10	0.11	0.49
Brazil	0.67	0.29	0.20	0.42	0.02	0.26
Chile	0.78	0.23	0.46	0.78	0.18	-
Colombia	0.70	0.14	0.18	0.31	0.12	0.32
Cuba	0.92	0.14	0.27	0.62	0.43	0.10
Honduras	0.60	0.09	0.09	0.11	0.03	0.41
Mexico	0.68	0.06	0.28	0.01	0.02	0.41
Paraguay	0.62	0.10	0.14	0.13	0.05	-
Peru	0.79	0.34	0.30	0.11	0.09	0.32
Dominican Republic	0.65	0.18	0.18	0.09	0.06	0.18
Venezuela	0.42	0.10	0.05	0.15	0.04	-
Urban						
Argentina	0.71	0.25	0.37	0.18	0.06	-
Bolivia	0.79	0.40	0.40	0.17	0.19	0.38
Brazil	0.70	0.33	0.24	0.41	0.03	0.20
Chile	0.85	0.28	0.56	0.70	0.19	-
Colombia	0.79	0.28	0.38	0.29	0.26	0.27
Cuba	0.90	0.15	0.34	0.75	0.60	0.06
Honduras	0.67	0.22	0.20	0.09	0.07	0.17
Mexico	0.76	0.08	0.37	0.00	0.02	0.43
Paraguay	0.67	0.15	0.22	0.14	0.06	-
Peru	0.80	0.41	0.40	0.11	0.11	0.26
Dominican Republic	0.76	0.27	0.26	0.08	0.08	0.18
Venezuela	0.44	0.12	0.07	0.13	0.05	-
Rural						
Argentina	0.33	0.00	0.11	0.22	0.00	-
Bolivia	0.57	0.00	0.00	0.00	0.00	0.64
Brazil	0.55	0.09	0.00	0.45	0.00	0.55
Chile	0.63	0.12	0.24	0.93	0.15	-
Colombia	0.63	0.03	0.03	0.32	0.00	0.35
Cuba	0.97	0.12	0.12	0.36	0.09	0.18
Honduras	0.55	0.00	0.02	0.13	0.00	0.58
Mexico	0.53	0.03	0.13	0.02	0.02	0.38
Paraguay	0.52	0.02	0.02	0.11	0.02	-
Peru	0.74	0.17	0.06	0.11	0.03	0.46
Dominican Republic	0.46	0.00	0.03	0.11	0.03	0.17
Venezuela	0.33	0.00	0.00	0.21	0.00	-

Source: author's estimations using data from PERCE (First Regional Comparative Explanatory Study). Latin American Laboratory for Assessment of the Quality of Education (LLECE).

Table 4

SCHOOL INFRASTRUCTURE IN LATIN AMERICA - 2006
(Share of Schools with different school facilities and utilities)

	Electricity	Water	Sewage	Landline	Enough restrooms	Sports facilities	Science Lab	Computer Lab	Dining Hall	Nurse Station	Library
All countries	0.89	0.80	0.61	0.49	0.69	0.64	0.13	0.37	0.29	0.06	0.53
Argentina	0.95	0.82	0.55	0.71	0.75	0.47	0.31	0.47	0.42	0.05	0.72
Brazil	0.95	0.88	0.62	0.58	0.81	0.69	0.13	0.39	0.33	0.02	0.52
Colombia	0.92	0.73	0.75	0.55	0.54	0.64	0.32	0.54	0.48	0.16	0.57
Costa Rica	0.97	0.88	0.72	0.72	0.61	0.48	0.03	0.30	0.93	0.06	0.24
Cuba	0.99	0.95	0.71	0.34	0.91	0.62	0.04	0.94	0.34	0.13	0.82
Chile	0.99	0.92	0.82	0.84	0.90	0.79	0.37	0.90	0.94	0.39	0.79
Ecuador	0.97	0.58	0.58	0.42	0.54	0.74	0.17	0.38	0.25	0.10	0.31
El Salvador	0.94	0.67	0.51	0.46	0.67	0.29	0.09	0.22	0.12	0.03	0.50
Guatemala	0.68	0.78	0.38	0.16	0.52	0.39	0.02	0.10	0.17	0.03	0.61
Mexico	0.97	0.80	0.67	0.41	0.66	0.70	0.02	0.31	0.13	0.04	0.53
Nicaragua	0.44	0.48	0.24	0.19	0.28	0.24	0.01	0.09	0.06	0.01	0.23
Panama	0.66	0.61	0.46	0.33	0.50	0.48	0.19	0.31	0.69	0.05	0.38
Paraguay	0.89	0.64	0.30	0.22	0.60	0.77	0.04	0.13	0.10	0.03	0.32
Peru	0.55	0.64	0.44	0.29	0.51	0.69	0.11	0.28	0.11	0.06	0.50
Dominican Republic	0.75	0.61	0.48	0.33	0.74	0.41	0.17	0.16	0.10	0.06	0.39
Uruguay	1.00	0.98	0.96	0.99	0.82	0.57	0.17	0.42	0.78	0.04	0.75
Urban											
Argentina	1.00	0.94	0.75	0.92	0.81	0.39	0.41	0.60	0.42	0.05	0.83
Brazil	1.00	0.95	0.84	0.86	0.90	0.86	0.22	0.64	0.46	0.04	0.74
Colombia	0.98	0.92	0.91	0.88	0.67	0.64	0.46	0.80	0.46	0.28	0.67
Costa Rica	0.99	0.96	0.84	0.98	0.77	0.61	0.09	0.77	0.92	0.18	0.57
Cuba	1.00	0.99	0.97	0.65	0.89	0.70	0.04	0.99	0.61	0.26	0.97
Chile	1.00	0.99	0.96	0.99	0.96	0.80	0.47	0.99	0.92	0.45	0.86
Ecuador	1.00	0.88	0.82	0.71	0.68	0.80	0.22	0.65	0.16	0.18	0.49
El Salvador	1.00	0.93	0.91	0.93	0.85	0.48	0.25	0.61	0.06	0.09	0.77
Guatemala	0.94	0.97	0.93	0.67	0.81	0.67	0.04	0.43	0.54	0.07	0.50
Mexico	0.97	0.97	0.89	0.70	0.77	0.77	0.04	0.46	0.11	0.08	0.57
Nicaragua	0.93	0.93	0.76	0.74	0.66	0.52	0.07	0.38	0.14	0.07	0.53
Panama	0.96	0.96	0.88	0.86	0.76	0.65	0.52	0.78	0.70	0.17	0.70
Paraguay	0.96	0.93	0.55	0.61	0.75	0.69	0.09	0.30	0.11	0.03	0.53
Peru	0.97	0.97	0.89	0.63	0.85	0.61	0.27	0.63	0.11	0.16	0.64
Dominican Republic	0.85	0.79	0.72	0.63	0.83	0.52	0.25	0.29	0.15	0.11	0.56
Uruguay	1.00	1.00	0.97	1.00	0.82	0.48	0.19	0.41	0.76	0.05	0.76
Rural											
Argentina	0.85	0.54	0.06	0.22	0.61	0.64	0.08	0.21	0.40	0.04	0.50
Brazil	0.88	0.79	0.33	0.20	0.70	0.45	0.02	0.06	0.16	-	0.22
Colombia	0.85	0.54	0.57	0.20	0.41	0.65	0.17	0.27	0.50	0.03	0.47
Costa Rica	0.96	0.83	0.67	0.60	0.53	0.42	-	0.08	0.93	-	0.08
Cuba	0.98	0.91	0.48	0.07	0.93	0.56	0.04	0.90	0.10	0.03	0.70
Chile	0.98	0.78	0.55	0.55	0.78	0.76	0.17	0.72	0.97	0.26	0.65
Ecuador	0.94	0.32	0.36	0.16	0.42	0.69	0.14	0.16	0.32	0.03	0.14
El Salvador	0.91	0.56	0.34	0.26	0.59	0.22	0.03	0.07	0.15	-	0.39
Guatemala	0.61	0.73	0.24	0.03	0.44	0.33	0.02	0.02	0.07	0.02	0.64
Mexico	0.97	0.63	0.44	0.09	0.53	0.63	-	0.15	0.16	-	0.48
Nicaragua	0.32	0.37	0.12	0.06	0.19	0.18	-	0.02	0.05	-	0.16
Panama	0.53	0.47	0.28	0.10	0.39	0.41	0.05	0.11	0.68	-	0.25
Paraguay	0.86	0.51	0.19	0.05	0.53	0.81	0.02	0.06	0.10	0.03	0.23
Peru	0.25	0.42	0.15	0.06	0.28	0.74	0.01	0.06	0.11	-	0.41
Dominican Republic	0.67	0.47	0.29	0.09	0.66	0.32	0.09	0.05	0.05	0.02	0.24
Uruguay	0.98	0.92	0.93	0.94	0.80	0.95	0.06	0.45	0.87	0.02	0.70

Source: author's estimations using data from SERCE (Second Regional Comparative Explanatory Study). Latin American Laboratory for Assessment of the Quality of Education (LLECE).

Table 5

SCORES ON INTERNATIONAL COMPARABLE TESTS, 2000-2012
(15 YEAR OLD STUDENTS)

Country	Subject	2000	2003	2006	2009	2012
Argentina	Reading	418		374	398	396
	Mathematics			381	388	388
Brazil	Reading	396	403	393	412	410
	Mathematics		356	370	386	391
Chile	Reading	410		442	449	441
	Mathematics			411	421	423
Colombia	Reading			385	413	403
	Mathematics			470	481	376
Mexico	Reading	422	400	410	425	424
	Mathematics		385	406	419	413
Peru	Reading	327			370	384
	Mathematics					368
Uruguay	Reading		434	413	426	411
	Mathematics		422	427	427	409

Source: Program for International Student Assessment (PISA) Results, U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics. Retrieved from http://nces.ed.gov/surveys/pisa/.

Table 6

STEPS USED TO SELECT PAPERS USED IN THE LITERATURE REVIEW

Review phase	Procedures Used	Number of papers: Developing Countries
1	Search EconLit and ERIC databases	8,820
	Potential studies kept (Round 1)	382
	Potential studies with our quality criteria	82
	Add papers included in Glewwe, Hanushek, Humpage and Ravina (2013) that were not in our list	27
	Add working papers written after 2010-2012	13
2	Review 122 full papers, eliminate papers based on lack of relevance, lack of quantitative analysis.	58
3	Eliminate papers based on methodology: lack of basic covariates. These 39 papers are the full sample.	39
4	Exclude papers that used OLS only. The remaining 19 papers are the "high quality" sample and include 4 RCTs.	19

Table 7

SUMMARY OF NUMBER OF PAPERS ANALYZING IMPACTS OF INFRASTRUCTURE VARIABLES ON EDUCATIONAL OUTCOMES

	Medium Quality	High Quality	RCTs
Classroom			
Desk/tables/chairs	4	2	-
Blackboards / flip charts / chalks	9	5	1
Roof / wall / floor	5	4	-
Classroom Library	2	2	-
School			
Overall school infrastructure	15	5	-
Library	8	6	1
Computers / laptops / internet	6	4	2
School amenities	8	4	-
Laboratories	2	2	-
Creation of new schools	3	3	-
Utilities			
Electricity	7	3	-
Drinking water facilities	4	3	-
Toilet facilities	4	3	-

Table 8

SUMMARY OF IMPACTS OF CLASSROOM INFRASTRUCTURE ON TEST SCORES

	Negative, Significant	Negative, Insignificant	Zero or missing. & no sign given	Positive Insignificant	Positive Significant	Total Papers
All studies						
Desk/tables/chairs	2(1)	2(1)	-	3(2)	1(1)	4
Blackboards/flipcharts/chalk	1(1)	17(5)	-	22(6)	8(3)	8
Roof / wall / floor	-	3(2)	-	1(1)	2(1)	3
Classroom Library	-	-	-	2(1)	-	1
High Quality studies						
Desk/tables/chairs	-	2(1)	-	2(2)	-	2
Blackboards/flipcharts/chalk	1(1)	6(2)	-	7(3)	1(1)	4
Roof / wall / floor	-	-	-	-	2(1)	1
Classroom Library	-	-	-	2(1)	-	1
RCTs						
Desk/tables/chairs	-	-	-	-	-	0
Blackboards/flipcharts/chalk	-	-	-	1(1)	-	1
Roof / wall / floor	-	-	-	-	-	0
Classroom Library	-	-	-	-	-	0
Latin America						
Desk/tables/chairs	-	-	-	1(1)	1(1)	1
Blackboards/flipcharts/chalk	-	2(1)	-	-	-	1
Roof / wall / floor	-	1(1)	-	1(1)	-	1
Classroom Library	-	-	-	-	-	0

Table 9

SUMMARY OF IMPACTS OF CLASSROOM INFRASTRUCTURE ON TIME IN SCHOOL

	Negative, Significant	Negative, Insignificant	Zero or missing. & no sign given	Positive Insignificant	Positive Significant	Total Papers
All studies						
Desk/tables/chairs	-	2(1)*	-	-	-	1
Blackboards/flipcharts/chalk	-	12(1)	-	14(2)*	2(2)	2
Roof / wall / floor	1(1)	12(3)	-	16(2)	3(2)	4
Classroom Library	-	-	-	-	-	-
High Quality studies						
Desk/tables/chairs	-	2(1)	-	-	-	1
Blackboards/flipcharts/chalk	-	12(1)	-	14(2)*	2(2)	2
Roof / wall / floor	3(1)	17(3)	-	11(1)	1(1)	4
Classroom Library	-	-	-	-	-	-
RCTs						
Desk/tables/chairs	-	-	-	-	-	0
Blackboards/flipcharts/chalk	-	-	-	-	-	0
Roof / wall / floor	-	-	-	-	-	0
Classroom Library	-	-	-	-	-	0
Latin America						
Desk/tables/chairs	-	-	-	-	-	0
Blackboards/flipcharts/chalk	-	-	-	-	-	0
Roof / wall / floor	-	-	-	-	-	0
Classroom Library	-	-	-	-	-	0

* signifies that we flipped one of the signs

Table 10

SUMMARY OF IMPACTS OF SCHOOL INFRASTRUCTURE ON TEST SCORES

	Negative, Significant	Negative, Insignificant	Zero or missing. & no sign given	Positive Insignificant	Positive Significant	Total Papers
All studies						
Overall school infrastructure	5(5)	7(6)	-	19(8)	30(7)	14
Library	2(2)	11(4)	-	6(3)	7(5)	7
Computers / laptops / internet	3(2)	15(3)	-	41(4)	20(5)	6
School amenities	7(4)	6(4)	-	4(3)	7(2)	7
Laboratories	1(1)	-	-	-	1(1)	1
Creation of new schools	-	-	-	-	4(1)	1
High Quality studies						
Overall school infrastructure	2(2)	4(2)	-	2(1)	6(2)	4
Library	1(1)	9(3)	-	6(3)	4(3)	5
Computers / laptops / internet	3(2)	15(3)	-	36(2)	18(3)	4
School amenities	3(1)	4(2)	-	3(2)	5(1)	4
Laboratories	1(1)	-	-	-	1(1)	1
Creation of new schools	-	-	-	-	4(1)	1
RCTs						
Overall school infrastructure	-	-	-	-	-	0
Library	-	4(1)	-	-	-	1
Computers / laptops / internet	3(2)	13(2)	-	36(2)	16(2)	2
School amenities	-	-	-	-	-	0
Laboratories	-	-	-	-	-	0
Creation of new schools	-	-	-	-	-	0
Latin America						
Overall school infrastructure	2(2)	2(2)	-	6(3)	21(3)	5
Library	1(1)	2(1)	-		3(2)	2
Computers / laptops	2(1)	9(2)	-	30(2)	31(3)	5
School amenities	2(2)	3(3)	-	2(2)	4(2)	4
Laboratories	1(1)	-	-	-	1(1)	1
Creation of new schools	-	-	-	-	-	0

Table 11

SUMMARY OF IMPACTS OF SCHOOL INFRASTRUCTURE ON TIME IN SCHOOL

	Negative, Significant	Negative, Insignificant	Zero or missing. & no sign given	Positive Insignificant	Positive Significant	Total Papers
All studies						
Overall school infrastructure	-	6(3)*	2(1)	3(3)*	1(1)*	4
Library	1(1)	2(1)	1(1)	7(2)*	4(1)	3
Computers / laptops / internet	1(1)	2(1)	-	2(1)	-	1
School amenities	-	-	-	1(1)	1(1)	1
Laboratories	-	2(1)	-	4(1)	6(1)	1
Creation of new schools	2(2)	4(1)	-	1(1)	9(2)	2
High Quality studies						
Overall school infrastructure	-	5(2)*	-	2(2)*	1(1)*	2
Library	1(1)	2(1)	1(1)	7(2)*	4(1)	3
Computers / laptops / internet	1(1)	2(1)	-	2(1)	-	1
School amenities	-	-	-	1(1)	1(1)	1
Laboratories	-	2(1)	-	4(1)	6(1)	1
Creation of new schools	2(2)	4(1)	-	1(1)	9(2)	2
RCTs						
Overall school infrastructure	-	-	-	-	-	0
Library	-	-	1(1)	-	-	1
Computers / laptops / internet	1(1)	2(1)	-	2(1)	-	1
School amenities	-	-	-	-	-	0
Laboratories	-	-	-	-	-	0
Creation of new schools	-	-	-	-	-	0
Latin America						
Overall school infrastructure	-	-	-	1(1)	-	1
Library	-	-	-	-	-	0
Computers / laptops	1(1)	2(1)	-	1(1)	-	1
School amenities	-	-	-	1(1)	1(1)	1
Laboratories	-	-	-	-	-	0
Creation of new schools	2(2)	4(1)	-	1(1)	9(2)	2

* signifies that we flipped one of the signs

Table 12

SUMMARY OF IMPACTS OF UTILITIES ON TEST SCORES

	Negative, Significant	Negative, Insignificant	Zero or missing. & no sign given	Positive Insignificant	Positive Significant	Total Papers
All studies						
Electricity	1(1)	7(4)	-	11(5)	9(3)	7
Drinking water facilities	-	6(3)	-	4(3)	-	3
Toilet facilities	-	11(3)	-	6(4)	16(3)*	4
High Quality studies						
Electricity	-	5(3)	-	9(3)	-	3
Drinking water facilities	-	5(2)	-	3(2)	-	2
Toilet facilities	-	1(1)	-	7(2)	2(1)	2
RCTs						
Electricity	-	-	-	-	-	0
Drinking water facilities	-	-	-	-	-	0
Toilet facilities	-	-	-	-	-	0
Latin America						
Electricity	1(1)	2(1)	-	2(2)	8(2)	3
Drinking water facilities	-	1(1)	-	1(1)	-	1
Sanitation facilities	-	-	-	1(1)	1(1)	1
Utilities Index	-	-	-	-	16(1)	1

* signifies that we flipped one of the signs

Table 13

SUMMARY OF IMPACTS OF UTILITIES ON TIME IN SCHOOL

	Negative, Significant	Negative, Insignificant	Zero or missing. & no sign given	Positive Insignificant	Positive Significant	Total Papers
All studies						
Electricity	-	4(1)*	-	-	-	1
Drinking water facilities	-	11(2)*	-	16(2)	3(2)*	2
Toilet facilities	1(1)	4(1)	-	18(1)	3(1)	1
High Quality studies						
Electricity	-	4(1)*	-	-	-	1
Drinking water facilities	-	11(2)*	-	16(2)	3(2)*	2
Toilet facilities	1(1)	4(1)	-	18(1)	3(1)	1
RCTs						
Electricity	-	-	-	-	-	0
Drinking water facilities	-	-	-	-	-	0
Toilet facilities	-	-	-	-	-	0
Latin America						
Electricity	-	-	-	-	-	0
Drinking water facilities	-	-	-	-	-	0
Sanitation facilities	-	2(1)	-	-	-	1
Utilities Index	-	-	-	-	-	0

* signifies that we flipped one of the signs

Table 14

SUMMARY OF IMPACTS OF INFRASTRUCTURE VARIABLES ON EDUCATIONAL OUTCOMES

(4 STUDIES FROM DEVELOPED COUNTRIES)

	Negative, Significant	Negative, Insignificant	Zero or missing. & no sign given	Positive Insignificant	Positive Significant	Total Papers
Classroom						
Desk/tables/chairs	-	3(1)	-	3(1)	-	1
Blackboards / flip charts / chalks	-	-	-	-	-	-
Roof / wall / floor	-	-	-	-	-	-
Classroom library	-	-	-	-	-	-
School						
Overall school infrastructure	-	-	-	-	-	-
Library	-	-	3(1)	1(1)	2(1)	1
Computers / laptops / internet	1(1)	-	-	3(1)	-	2
School amenities	-	-	-	-	-	-
Laboratories	-	-	3(1)	-	3(1)	1
Creation of new schools	-	-	-	-	-	-
Utilities						
Electricity	-	-	-	-	-	-
Drinking water facilities	-	-	-	-	-	-
Toilet facilities	-	-	-	-	-	-

Appendix I: Search Terms for Developing Countries

Infrastructure: computer, bathroom, bench, blackboard, building condition, chair, chalk, desk, electric, facilities, floor, internet, lab, laboratory, labs, laptop, library, plumbing, roof, school infrastructure, school inputs, school resources, table, wall, window, access to computers, acoustics, air conditioning, auditorium, busing, cafeteria, charts, classroom environment, classroom size, climate control, dining facility, educational environment, energy, equipment, facility improvement, fan, food service, furniture, heat, light, maintenance, natural light, physical environment, playground, pollution, recreational facilities, recycling, sanitary facilities, school buses, school construction, school health services, school security, school size, school space, structural elements, technology, temperature, testing accommodations, transportation, trash, utilities, vehicles, ventilation, water quality, water, building age, adjacent facility, color , colour, noise, site acreage, landscaping, school grounds, graffiti, graffiti removal, interior painting, exterior painting, locker conditions, toilet, sport field.

Educational Outcomes: academic achievement, ability, absence, achievement, aptitude, attendance, bullying, cheating, cognitive skills, completion, conflict, crime, delinquency, dropout, enrollment, enrolment, grades, graduation rate, literacy, school days, school hours, performance, repetition, safety, violence, scores, learning, security, student promotion, thinking skills, time factors, time in school, time to graduation, retention, dropping out.

Developing Countries: Afghanistan, Albania, Algeria, Angola, Antigua and Barbuda, Argentina, Armenia, Azerbaijan, Bahamas, Bahrain, Bangladesh, Barbados, Belarus, Belize, Benin, Bhutan, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Brunei Darussalam, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Cape Verde, Central African Republic, Chad, Chile, China, Colombia, Comoros, Congo, Costa Rica, Côte d'Ivoire, Croatia, Djibouti, Dominica, Dominican Republic, Ecuador, Egypt, El Salvador, Salvadoran, Equatorial Guinea, Eritrea, Ethiopia, Fiji, Gabon, Gambia, Georgia, Ghana, Grenada, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, India, Indonesia, Iran, Iraq, Jamaica, Jordan, Kazakhstan, Kenya, Kiribati, Kosovo, Kuwait, Kyrgyz Republic, Lao People's Democratic Republic, Latvia, Lebanon, Lesotho, Liberia, Libya, Lithuania, Macedonia, Madagascar, Malawi, Malaysia, Maldives, Mali, Mauritania, Mauritius, Mexico, Moldova, Mongolia, Montenegro, Morocco, Mozambique, Myanmar,

Namibia, Nepal, Nicaragua, Niger, Nigeria, Yugoslav, Oman, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Qatar, Romania, Russia, Rwanda, Samoa, São Tomé and Príncipe, Saudi Arabia, Senegal, Serbia, Seychelles, Sierra Leone, Solomon Islands, South Africa, Sri Lanka, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Sudan, Suriname, Swaziland, Syrian Arab Republic, Tajikistan, Tanzania, Thailand, Timor-Leste, Togo, Tonga, Trinidad and Tobago, Tunisia, Turkey, Turkmenistan, Uganda, Ukraine, United Arab Emirates, Uruguay, Uzbekistan, Vanuatu, Venezuela, Vietnam, Yemen, Zambia, Zimbabwe, North Korea, Cuba, Syria.

Appendix II: Search Terms for Developed Countries

In addition to the infrastructure and educational outcomes listed for the developing country search, the following search terms were included:

Developed Countries and Regions: U.S., US, District of Columbia, D.C., DC, Washington DC, Washington D.C., Alabama, Alaska, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, Florida, Georgia, Hawaii, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin, Wyoming, UK, U.K., United Kingdom, Great Britain, Britain, England, Scotland, Wales, Northern Ireland, Europe, Cyprus, Malta, Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Iceland, Ireland, Israel, Italy, Japan, South Korea, Korea, Taiwan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Slovak Republic, Slovenia, Spain, Switzerland, Sweden, Greece.

Methodological: Regression, RCT, randomized controlled trial, fixed effects, propensity score, instrumental variables, panel data, differences-in-differences, differences in differences, IV, matching methods, discontinuity design.