EENEE *Ad-hoc* Question

Returns on Investment in Education
(literature review)

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1. Introduction

The governments of the OECD countries spend annually between 4% and 8% of their GDP on public education. At the same time, people spent an increasing portion of their lives in education. The average length of schooling across advanced economies has increased from 5.6 to 11.05 during the past five decades (Barro and Lee 2010), partially as a response to the expansion of compulsory schooling laws, but mainly as a result of individual's self-interest. The incentives of states and individuals in investing in education are different. The formers hope to improve the wealth and wellbeing of the nation, by stimulating productivity and innovation, reducing crime, promoting social cohesion, civic responsibility, healthy life and pro-social behaviour (among other things). Individuals consider own life success and social status, often focused on monetary rewards and life satisfaction. In particular, individuals do not take into consideration the broader implications of their choices for the society. Moreover, people often underestimate their true benefits from education (Jensen 2010). Consequently, *social* returns from education are likely to be higher than *private* and relying only on the latter would lead to a sub-optimal level of investment (Acemoglu and Angrist, 2000; Psacharopoulos and Patrinos, 2018). This is the main rationale for public spending on schooling (e.g. Acemoglu 1996).[1]

The general level of spending on education matters for student outcomes. For instance, a study on the US by Jackson et al. (2016), shows that a 10% increase in per pupil annual public spending causes an increase in the length of schooling by 0.31 years, around 7% higher earnings, and a 3.2 pp. reduction of adult poverty. But how much should governments spend on public education? Which stages of education should be prioritized? Should we emphasize the quantity or rather the quality of education? There are no unique answers to these questions, as they are conditional on particular institutional environment and our choice of outcomes (Hanushek 2003).

This work tries to summarize the literature on the rate of returns from public investment in education on various outcomes, including student achievements, wages or employability. The focus is on public expenditures, but it encompasses all stages of education from kindergartens to life-long learning. In addition, only works looking at individual outcomes are considered, although there is an extensive literature looking at the effect of education on macro outcomes, such as GDP growth (e.g. Lucas 1988; Barro and Sala-i-Martin 1999; Valero and Van Reenen 2019). The main conclusions from this review are:

[1] In addition, governments might also want to fund education for "noneconomic" reasons, such as equity ("levelling the playing field"), politics (e.g. promoting certain values) or culture (e.g. nation building).

- The returns from public investment in education decrease with the length of education. That is, there are lower for tertiary than for primary education. Preschool education and early childhood interventions are especially important for cognitive and non-cognitive development, as well as outcomes achieved during adulthood.

- Different types of investment matter differently for countries at different stage of development. Investments in schooling infrastructure and educational materials are crucial for low- and middle-income countries, but not so much for high-income countries. On the other hand, the reverse seems to be true for investment in teacher quality or class size.

- Public education matters not only for cognitive and non-cognitive development of individuals or labour market outcomes, but also for a healthier society. This is true for all levels of education.

- Investing in teacher quality seems to be one of the most effective ways of improving student's performance.

- The reduction of class size has, in general, a positive effect on student outcomes, but it is not always justified on the basis of cost-effectiveness analysis.

- There is no evidence investment in new types of learning materials, such as interactive whiteboards, computers or specialized software, improves students' outcomes.

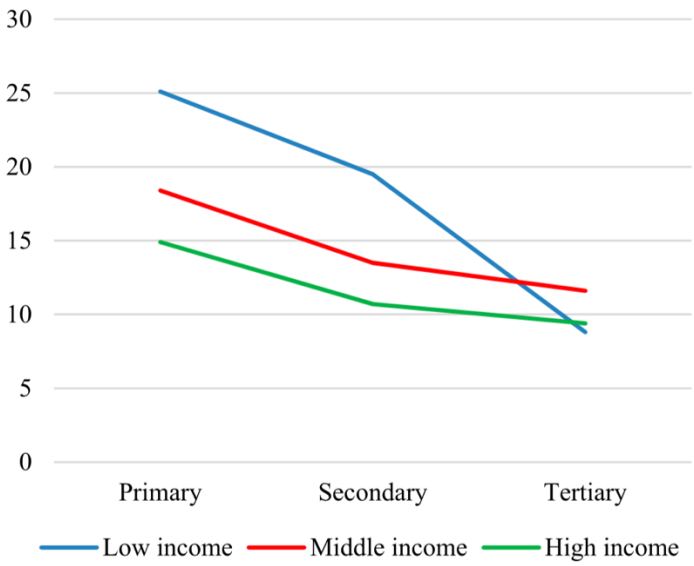
The review is organized as follows. Section 2 discusses the effect of the quantity of education on labour market outcomes, students' achievements and health. Section 3 analyses the literature on the level and design of teacher compensation, and Section 4 analyses the literature on teacher quality. Section 5 discusses studies looking at the effect of class size, whereas Section 6 focuses on school infrastructure. Section 7 briefly mentions some influential critique of public investment in education. Section 8 concludes.

2. Quantity of Education

The quantity of education is of fundamental importance for many life outcomes. Below I highlight the most important conclusions from the studies looking at the effect of the length of schooling on the situation of people on the labour market, student's achievements and health.

Labour market outcomes. There is an enormous literature looking at the effect of (public) education on wages (see e.g. Card 1999; Harmon et al. 2000; Psacharopoulos and Patrinos 2004; 2018). I start with presenting the main findings from this literature. Figure 1 from Psacharopoulos and Patrinos (2018) shows the estimates of social returns from schooling – that is the wage increase resulting from completing an educational stage - across stages and levels of country development (i.e., the averages from many studies). The results have fundamental importance for the structure of public spending on education. First, the rates of returns are sizeable, ranging from 10 to 25%, highlighting the need for government intervention. Second, the returns from schooling are diminishing with the level of education, suggesting that relatively more public money should be directed towards early stages of education. Third, the returns tend to be, on average, lower in more developed economies (except tertiary education), implying that public investment should be especially important for developing countries.

Figure 1 (Fig 10 in Psacharopoulos and Patrinos (2018), p 455): The structure of social returns, by level of education and level of development.



It is therefore tempting to conclude that governments should invest more in more developing countries (Strauss and Thomas, 1995). This claim, however, might be false as the expansion of education clearly affects the rate of return from schooling. In a seminal paper investigating the role of public expenditures on education in developing countries, Esther Duflo (2001) estimates the effect of the massive 1973' public primary school construction project in Indonesia (INPRES) on schooling and labour market outcomes. The program, which costs represented 1.5 percent of the Indonesian GDP in 1973, increased in five years enrolment rates among children aged 7-12 by 14 pp. The results on the labour market outcomes were equally impressive. The author exploits between-cohort differences across areas with different program intensity (difference-in-differences) to estimate the causal effect of the program. She finds that each new school constructed per 1,000 children led to a 1.5-2.7% increase in wages, implying the rate of returns from an additional year schooling of around 7-11%.

While the wage effects connected with a massive expansion of primary education seems to be positive (i.e., people are more productive). The general equilibrium effects connected with the massive expansion of secondary and tertiary education make the predictions more ambiguous (i.e., will be affected by the interplay of productivity gains, growing supply of educated workers and all various spillovers). In a seminal works on the US, Katz and Murphy (1994) and Goldin and Katz (2008) show that the expansion of tertiary education in the 1970s led to a decline in educational wage premium. Nevertheless, in the 1980s this trend was reversed, as the downward pressure on the wage premium from the growing supply of educated workers, was counterbalanced by the growing demand for them caused by skill-biased technological change (Acemoglu 2002). Similar trends have been observed for other developed countries (Freeman and Katz 2007). The evidence from developing countries, for instance from China (Ou and Zhao 2016), show that the expansion of universities decreases unemployment not only for college graduates, but also for high-school graduates. However, there are also distributional effects. On the one hand, the expansion decreased college wage premium, reducing overall wage inequality. On the other hand, it decreased women's employment ratio, negatively affecting gender inequality. A fall in wage inequality following the expansion of secondary

and higher education is also documented for Brazil (Jaume 2018), where it additionally contributed to a significant reduction of poverty.

With respect to preschool education, Heckman (2013) shows that early childhood interventions might have large effects on labour market outcomes. Tavnes and Mogstad (2011) document that the expansion of subsidized childcare in Norway had positive effect on children's educational attainment and labour market participation.

Student Achievement. Heckman (2013 provides exhaustive evidence for the crucial role of preschool education in cognitive and non-cognitive development of children. Berlinski et al. (2009) show that the large expansion of universal pre-school education in Argentina had a strong and positive effect on performance of students and their self-control during subsequent primary education. One extra year of pre-school education increases primary-education test scores by 0.23 of standard deviation. Berlinski et al (2008) exploit Urugayan data and use within-family variation in the length of preschool education, which originated from rapid expansion in the public supply of pre-primary school places. They find that preschool attendance increases the total length of schooling by 0.8 year and sizeably decreases the likelihood of early drop-out. In a similar vein, Cascio and Schanzenbach (2013) evaluate the expansion of public pre-education in the US and conclude that the larger access to kindergartens not only positively affects the future student achievements, but also might increase and improve time spent by mother with her children. Similar results for the US are also reported by Kline and Walters (2016).

Health. Grossman and Kaestner (1997), Grossman (2000) and Grossman (2006) provide an extensive literature review of studies linking the length of schooling with health outcomes, such as mortality rate or self-reported and physiological evaluation of health. The main conclusion is that education is the main correlate of good health, more important than occupation or income. This is true for children health (affected also by parental education) and adult health. The main mechanisms are that education increases income and thus raises the potential cost of bad health (i.e. opportunity costs) and improves knowledge about healthy lifestyle. But education might also affect time preferences and sense of control, which are crucial factors affecting addictions (e.g. smoking, alcoholism) and ability to develop good habits (e.g. exercising). Physical health and mental health seem to particularly benefit from tertiary education. As shown by Case and Deaton (2017), in the US during the past few decades, the mortality and morbidity rates among white non-Hispanic population has been rising among for those without a college degree and falling for those with a college degree. This gap in mortality is to large extent driven by suicides, drug overdoses, and alcohol-related liver mortality.

While these general conclusions refer to the total investments in education, they are also confirmed in settings where the expansion of public and compulsory education is being investigated (Adams 2002; Spasejovic 2003; Arendt 2005; Lleras-Muney 2005). In particular, Breierova and Duflo (2004) use the above-mentioned Indonesian INPRES program and find significant and negative effect of publicly-funded education on infant’s mortality, both for mothers and fathers. In other study, Osili and Long (2008) show that the introduction of universal primary education in Nigeria reduces early fertility by 0.26 births.

3. Teacher Salaries

The expenditure on teacher's compensation constitute the largest part of public spending on education across the OECD countries. A high teacher salary can affect student's outcomes mainly through the higher chances of attracting and retaining high-quality teachers.[2] Increasing relative salary (i.e., compared to the local labour market) may also improve the social status of the profession. In addition, performance-related compensation, for instance, linking wages with teacher's value-added, can be used to elicit higher effort from the teachers (Muralidharan and Sundararaman, 2011). Yet, the older evidence on the effectiveness of the level and structure of wages is often mixed, partially resulting from the endogeneity issues (Hanushek 2003; 1997; Woessmann 2011, Rothstein 2015). The new wave of research has put more attention at removing the bias, and, in general, find that student's outcomes can be responsive to teachers' salaries. Below I highlight the most influential studies, which focus almost exclusively on the test-measured performance of students.

The recent evidence from the cross-country studies point to the importance of teacher salaries. Dolton and Marcenaro-Gutierrez (2011) exploit variation in teacher wages across the OECD countries. They show that a 10% increase in teacher wages leads to a 5-10% increase in student performance, as measured by PISA or TIMSS test scores. Similar results are shown by Woessmann (2011), who uses cross-country data on teacher salaries and type of compensation from PISA. The author shows a positive association between the level of wages and student performance, which is strengthen when the performance-related pay system is in use. Linking teachers' wages with students' performance has been also proven effective in a study of India by Muralidharan and Sundararaman (2011). Besides directly aligning teacher's monetary incentives with learning outcomes, such wage schemes may also improve teaching quality by informing teachers about their performance (Taylor and Tayler, 2012).

Turning into country-specific studies. Britton and Propper (2016) use registry data on almost all schools in England and show that school-level performance reacts to changes in relative teacher wages. A 10% shock to the wage gap leads, on average, to a 2% increase in student performance. Using data from Brazil, Harbison and Hanushek (1992) show that increasing teacher salaries has positive impact on student performance. Doubling salaries raises score in reading and mathematics by 0.14-0.15 of standard deviation. A study of Texas by Hendricks (2014) shows that high salaries reduce teacher turnout, which positively affects student performance. An analysis on the state of Illinois in the US (RAND Education 2006), shows a positive correlation between teacher wages and district-averages of performance, after controlling for a battery of student, school and district level outcomes.

With respect to other student outcomes, Loeb and Page (2000) show that increasing teacher wages by a 10% can reduce early high school dropout rate by around 4%. Card and Krueger (1992) look at the relationship between the US-state level returns from one extra year of schooling and public investment in teacher salaries in primary and secondary education. Their main measure is the average teacher wages in a given state relative the state's average wage. They find that doubling relative wage of teachers increases the rate of return by around 0.9 percentage point.

[2] Although sometimes the level of salary matters less than the type of job contract. Muralidharan and Sundararaman (2013) show evidence from India, and Duflo et al. (2015) from Kenya, that hiring local teachers on annual performance-conditional contracts for one-quarter of the market wage has a positive effect on the performance of students. The channel is through relatively high effort exerted by contract teachers.

4. Teacher Quality

High teacher wages are not sufficient to create a high-quality teaching (Hanushek and Rivkin 2004). The government must also ensure a proper screening of candidates for the profession and provide teacher training. In particular, the latter has been shown to matter a lot for student achievements. However, the recent debate on teacher quality has been focused on the measurement of teacher value-added and its potential use in education (Koedel et al. 2015). For instance, selecting and promoting teachers based on their value-added were advocated (see e.g. Gordon et al. 2006).

The first (and also older) stream of literature focuses on direct measures of teacher quality, for instance, direct assessment or the level of teacher's education or experience. Hanushek et al (2018) provide evidence from 31 countries that teacher's cognitive abilities are strongly related to student performance. In other recent study, Araujo et al. (2016) randomly assign 24000 students to teachers, next the authors video-record teachers' performance and construct a measure of teacher quality. They show that a one standard deviation increase in teacher quality leads to a 0.07-0.11 standard deviation increase in student performance. Earlier studies on Brazil (Harbison and Hanushek 1992), Jamaica (Glewwe et al 1995) and India (Kingdon 1996) show a positive effect of teacher education and training on student achievements. Using an experiment with random assignment of remedial teachers in India, Banerjee et al. (2007) show that the exposure of children to such teachers instantaneously increases their performance by 0.28-0.45 of standard deviation, and the effect remains significant after one year. Moreover, the positive effect is much larger for low-performing students, than for high-performing students. The evidence is mixed on the relative effectiveness of investment in general or school-specific skills. Regarding the latter, a study of Israeli schools by Angrist and Levi (2001) shows that providing on-the-job training to teachers and developing learning centres for failing students, can improve learning outcomes. On the other hand, Jacob and Lefgren (2004) use regression discontinuity design to estimate the effect of on-the-job teacher training in Chicago's high-poverty areas, which developed skills related to particular teaching content and broader pedagogical skills. The authors show no effect of the training on student performance, suggesting that general skills are relatively more important. This is also in line with earlier studies by Glewwe and Jacoby (1994) of Ghana and Glewwe et al. (1995) of Jamaica, which show that most teacher-level variables[3] do not significant influence student performance.[4]

The more recent literature looks at the effect of teacher quality estimated by teacher value-added, that is, on average, by how much a teacher increases the performance of students. In seminal works, Chetty et al. (2014a; 2014b) use registry data from the US to look at the relationship between teacher value-added and a range of long-term outcomes. The authors find that students who had high-quality teachers have higher college attendance, higher earnings, and are less likely to have teenage-pregnancy. The effect on wages is substantial, replacing a teacher from the bottom of the distribution of quality with the average teacher, would increase the present value of classroom's lifetime income by around $250 000. Aaronson et al. (2007) identify "high-quality" teachers in the Chicago public high school system and show that they have positive effect on student performance, especially for those with lower abilities. A one standard deviation improvement in teacher value added leads to an increase in student's performance corresponding to 22% of the average annual gain. Similar results are reported by Rockoff (2004) for New Jersey. Hanushek (2004) and Rivkin et al. (2005) use data from Texas

[3] These included teacher experience and teacher schooling or degrees.
[4] Except the Jamaican study, which shows a strong positive effect of teacher training on reading, but not on math.

and estimate that having a good teacher (compared to an average one) for five consecutive years would remove the negative effect of being from a low-income family on achievement. The effect of increasing teacher quality by one standard-deviation is comparable to the costly reduction of class size by ten students.

5. Class Size

Public spending on class size reduction has been one of the most popular forms of public investment in education.[5] The main arguments are that smaller classes improve student outcomes as they lead to less distraction, better tailored teaching and more teacher's attention. Nevertheless, it is one of the most expensive forms of improving student outcomes. While most of the literature reports positive effects of decreasing class size, and this effect is consistent across stages of education and countries, there are few very influential works showing no relationship (Jepsen 2015). In this section I review the most important works and finding from this extensive literature.

Student achievements. The best quality evidence on the effect of class size reduction on student achievements comes from experiments in which students were randomly assigned to classes of various size. An early influential example is Tennessee STAR programme, where a reduction of class by one student led to increase of student achievements by around 0.05 of standard deviation (Krueger 1999; Jepsen and Rivkin 2009; Chingos 2013).

Another stream of influential papers uses quasi-experiments to identify exogenous changes in class size. For instance, Angrist and Lavy (1999) use discontinuities in classroom assignment rules (Maimonides's rule) in Israel and show that reduction of classroom size by one student increases student performance by between 0.018 - 0.036 of standard deviation. Similar, but heterogenous and sometimes not-distinguishable from zero, findings from the classroom size rules reported for Sweden (Fredriksson et al. 2012), Denmark (Browning and Heinesen 2007), France (Gary-Bobo and Mahjoub 2013), Norway (Bonesronning 2003; Leuven et al. 2008) and the Netherlands (Dobbelsteen et al. 2002).

On the other hand, Woessmann and West (2006) look at 11 European countries and find little evidence for a relationship between class size and student performance.[6] Exploiting class size variation caused by changes in the size of cohorts and class size rules, Hoxby (2000) shows no systematic relationship between class size and student achievements. Using a similar method, Hanushek and Rivkin (2005) report very small positive effects - of around 0.005-0.01 of standard deviation. A study of Florida by Chingos (2012) shows that schools, which were obliged to reduce class size did not experience any significant improvement in student performance. Similar conclusions are drawn from early meta-studies of the literature on class size (Fuller and Clark 1994, Harbison and Hanushek 1992).

Labour market outcomes. Using Tennessee STAR experiment, Chetty et al. (2011) show that smaller classes in kindergarten and primary school have strong and positive effect on college attendance, but relatively small effect on wages. Much larger effects on wages are reported for

[5] For instance, as reported by Hoxby (2000), in 1996 California spent 1 billion dollars on this purpose. One reason for its popularity is that this policy is popular among students parents and teachers and so it can be relatively easily implemented.

[6] Interestingly, the only countries with a positive effect of class-size reduction are Italy and Ireland, countries with relatively low teacher wages.

Sweden by Fredriksson et al. (2012), who conclude that a reduction in class size from 25 to 20 pupils increases earnings of almost 18%.

The non-experimental literature is larger. Card and Krueger (1992) look at the relationship between the US-state level returns from one extra year of schooling and public investment in pupil/teacher ratio (class size) in primary and secondary education. They show that decreasing the pupil/teacher ratio by 10 students increases the rate of return by about 1 percentage point. However, Heckman et al. (1996) show that the estimated positive earnings-school quality relationship can be very sensitive to specific functional choices. Two studies look at the effect of class size and wages using the British National Child Development Survey. The first by Dearden et al. (2002) report no effect of smaller school size on wages for men, but a positive effect for women, especially for those of lower ability. The second by Dustmann et al. (2003), first establish a positive and strong effect of smaller classes on tertiary education attendance, and, based on this channel, they estimate a positive effect on future wages.

6. Infrastructure

Psychical school infrastructure is the most fundamental form of public investment in education, as it provides the actual space for learning. A dense school network decreases the distance to schools, which positively affects attendance and allows students to spend more time on studying. It also creates stronger ties between schools, parents and local communities. But school buildings must also provide safe and healthy environment to children, should be equipped with educational materials, and offer library, gym or area for outside activities. The exhaustive summary of the evidence is provided by Barret et al. (2018) and Schneider (2002). An earlier meta-analysis by Earthman (2002) concludes that students attending schools with poor quality of infrastructure score on average 5-17% lower than their peers in schools of standard quality. Below, I highlight the most important studies.

The effect of building quality on student performance varies across developed countries. A study by Hopland (2013) uses TIMSS data and shows that, on average, poor building conditions have negative (but insignificant) effect on student performance. However, the magnitude is much larger in Australia, the Netherlands and Japan, than in Belgium, the UK, Italy or New Zealand. The same author also shows a negative effect of bad quality of school infrastructure on student achievements in Norway (Hopland, 2012). Cellini et al. (2011) looks at California's school districts and exploits referenda from on funding public investment in school infrastructure (regression discontinuity design). They document that districts, which narrowly accepted the funding saw an immediate improvement in student achievements and a substantial increase in local house prices. Similar findings for the US are also reported in Jones and Zimmer (2001).

The public investment in new types of learning devices, such as interactive whiteboards, computers or specialized software, is often motivated by claims that they improve student outcomes and help acquiring new skills demanded on the labour market. The evidence does not support this claim. Using introduction of computerized classes in Israel, Angrist and Lavy (2002) show that although teachers were more likely to used computer-aided instruction, this intervention had no effect on students' achievements. Johnson et al. (2019) evaluate an IT-program designed to support teaching assistants in the UK. The authors show that the IT-program was less effective than a standard paper material. Berlinski and Busso (2017) evaluate a set of innovative pedagogical interventions in Costa Rica, including interactive whiteboards or providing computers to students. The results show that students in control group, who did

not experience any innovation, outperformed those from the treatment groups. Similar results are reported by Rouse and Krueger (2004), who look at the effect of a computer program designed to enhance reading skills. On the other hand, a quasi-experimental research from Turkey by Ercan (2014) shows that the introduction of specially-designed multimedia learning materials boosts student performance and reduces gender gap in student outcomes.

The evidence from developing countries is less mixed than from the OECD countries. A study of Brasil by Harbison and Hanushek (1992) find positive effects of the quality of public-school buildings and availability of writing materials (e.g. chalks, pens) on student achievements in reading and math. Similar findings for are reported for Ghana by Glewwe and Jacoby (1994) and India by Kingdon (1996).

7. Critique

The alternative view on education is presented by the signalling model of education (Spence 1978). In this class of models, education does not increase productivity and is only used by high-able individuals to signal their skills to the employers. As such, public spending on education is socially wasteful, as the social returns to education are not different from the private returns. Although there is some influential empirical evidence showing that education is used to signal ability (Tyler et al. 2000), the consensus, is that it is highly unlikely that education would not increase productivity and other outcomes important from the societal point of view (Acemoglu and Angrist 2000).

The other line of critique discusses whether public spending in the quality of education is efficient. Although Betts (1995) finds that it matters for white male American worker's earnings what was his high-school, the effect cannot be explained by teacher salaries, teacher quality nor class size. Grogger (1996) looks at the black/white wage gaps in the US and concludes that, in general, school inputs have no effect on neither level of wages nor the convergence of earnings between races. Also, a meta-analysis of more than 90 early studies by Hanushek (1996) concludes that "[s]imple resource policies hold little hope for improving student outcomes,"

8. Summary

The existing studies show that public spending on education is crucial for the development and wellbeing of people, and, therefore, it is also a key source of the nation's wealth. As such, we should think about public education as a form of investment, not merely as a consumption of common resources. We should also realize that the necessity for this investment has not diminished. In particular, with fast technological change and automatization that make many occupations obsolete, high-quality and inclusive education becomes of crucial importance. With growing global migration, public education is a tool for building well-functioning, vibrant and cohesive society. With stagnating productivity across developed countries, improving education can bring back the healthy stamina into the economies. It is very important to remember about these during the times of austerity, when education has to compete for resources with other public spending goals.

The important task is to understand, which forms of public investment in education yield the highest rates of return. This review shows evidence for various types of public spending: the quantity of education, teacher salaries, teacher quantity, class size and school infrastructure.

There are no simple answers, as they depend on the outcome of interest, the stage of education and the state of country's development. There are relatively few generalizable rules: (i) the earlier the investment takes place, the higher the returns, and especially important is preschool education; (ii) investing in teacher quality seems to be one of the most effective ways of improving student's performance; (iii) the reduction of class size has a positive effect on student outcomes, but it is relatively costly; (iv) there is no evidence that investment in new types of learning materials or devices improves students' outcomes; (v) what works in developed economies, might not necessary work in developing countries. Finally, this review highlights the role of education policy based on knowledge, which goes beyond the relatively short cycle of democratic governance.

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