CHAPTER 1.12

Trusting the Unknown: The Effects of Technology Use in Education

FRANCESC PEDRÓ
UNESCO

Governments have been investing in educational technology since the early 1980s.[1] The devices, services, and applications of this technology are constantly evolving, and schools and classroom arrangements continue to develop in order to take advantage of it. The increasing emphasis on personal ubiquitous access to connectivity for communication and information purposes, coupled with the evolution of technology and lower prices, contribute to modifying the context in which investment decisions about educational technology—the technology policies in education—have to be made.

When reviewing these policies, it is striking how little is known about the effects of using technology on the quality of school education,[2] and, more specifically, which particular uses of technology can result in better student performance. If a good evidence-supported knowledge base existed in this domain, then the analysis of these effects, and the factors that determine or condition them, could be used to unveil what works and why. But in the absence of hard evidence, the evaluation of these policies remains an almost impossible endeavor and the whole issue of how these policy decisions are made remains open.

This chapter addresses two questions. First, it looks at what is currently known and the limitations of the existing knowledge base—recognizing the paradox that developing countries, which make comparatively bigger efforts in this domain, lag behind also in terms of knowledge base. Second, it considers both what elements are missing and how the important methodological challenges required to assemble them could be met.

WHY TECHNOLOGY POLICIES MATTER IN EDUCATION

During the past 30 years, governments have made important efforts to support school technology adoption. Typically,[3] school technology policies have involved the acquisition of equipment and networks; the provision of teacher-training programs and teacher-support schemes; and, lately, the development of digital content by public institutions, the private sector, or teachers themselves. There are no estimates about the total amount of these investments, although some data, such as the ratio of students per computer, can provide a very rough indication if compared internationally. No doubt, for most developed and middle-income countries a serious effort has been made; it is likely that the scale of the effort in low-income countries may be proportionally higher.[4]

The rationale for such investments relies on a number of assumptions about the role that school could play in key areas for economic and social development if technology was used in teaching and learning to a significant extent.[5] First, from an economic perspective, it is assumed that the emerging model of the knowledge economy requires not only an increased proportion of digitally skilled workers, but also the development and acquisition of new skills that depend on, or can be fostered by, technology-enhanced or supported learning processes.[6] It is therefore expected that schools will provide adequate learning opportunities for this acquisition.

Second, from a social perspective, schools have always been seen as a crucial bastion in the struggle against the digital divide, which was originally seen as the gap between those who have access to technology and those who do not. Nowadays, the concept of digital divide has been expanded to include a second definition, according to which the real divide relates not to access but to the ability to benefit from use: young people with equal access to technology could benefit from it in different ways according to their socioeconomic backgrounds and, in particular, to peer pressure. School education is expected to offer compensatory opportunities to perform better for those unable to benefit as intended from technology.

Third, the concept of culture itself has evolved dramatically because technology has not only a direct impact on cultural contents, by generating new forms of cultural expression, but also an indirect impact on the relationships that people have with culture, by allowing every individual to consume and produce, indistinctly, digital content. If school education is expected, among other things, to allow people to benefit from culture, it follows that schools have a role to play and therefore should do their best to address the issues posed by digital culture. And fourth, a policy perspective also has to be considered, because civic values are being challenged by technological developments and, on top of this, citizens are increasingly required to operate in contexts of e-democracy or e-administration. Schools can be seen in this respect as providing an environment where these values can be learned experientially.

Given the scale of the challenges, any of these assumptions would in fact suffice to justify the public efforts made to incorporate technology into school education. However, if there is one key assumption behind technology policies in education, it is that technology, if adequately used, can boost the quality of school education. This improved quality would be the result either of a higher efficiency of teaching and learning or of dramatic changes in the nature of the processes involved, leading to a paradigm shift in education. To sum up, students would learn more, better, or even differently, thanks to technology.

THE EXISTING KNOWLEDGE BASE

As in many other areas of public policy, the education sector has been subject to an increasing public scrutiny in which data and indicators both play a major role. Policymakers can now look at an expanding knowledge base that allows them to make informed decisions on the basis of benchmarking indicators.[7] They could also benefit from a dedicated (sub) set of indicators in education that would allow to them to benchmark inputs, processes, and outcomes in relation to technology policies in education, and situate all of these factors in an appropriate context. If the overarching policy ambition is that students learn more, better, or even differently thanks to technology, then the corresponding indicators should provide factual information about the extent to which this is actually happening; in sum, they should tell the whole story about the effects of technology in education—or at least provide useful indications.

Given the importance of the policy goals and the assumptions made, it could be expected that there would be an ever-growing knowledge base about the effects of technology policies in education. Yet the reality is that even the most well known international sources for education indicators lack basic information about technology policies in education. For developed countries, neither the Organisation for Economic Co-operation and Development (OECD) nor the European Commission has a comprehensive set of indicators (that is, one involving inputs, processes, and outcomes), although they both are increasingly improving the dataset to include, for instance, assessments of student performance in digital skills. In fact, the OECD's Programme for International Student Assessment (PISA) dataset remains the most reliable source of information on access, use, and outcomes in this domain,[8] despite its limitations in terms of geographical coverage and reliability,[9] and its inadequacy regarding current classroom practices.[10]

For developing countries, the situation is even worse. UNESCO has only recently begun some regional initiatives intended to provide at least a comparative worldwide perspective of access to computers and the Internet in schools, while the World Bank's System Assessment and Benchmarking for Education Results (SABER) initiative and the Inter-American Development Bank are currently focusing in a compilation of detailed information about technology policies in education, mostly from a qualitative perspective. Unfortunately, neither of these initiatives has yet produced tangible results.

As has been pointed out several times—for developed countries,[11] as well as developing ones[12]—the existing knowledge base is quite scattered and limited in scope: it covers only some of the important aspects related to the inputs (how many devices have been sent to schools, for example); it provides only very limited information about the processes (how many students per device, for example); and it is rather confusing, if not biased, in relation to the outcomes (the effects of technology use on student performance).

The three reasons that the knowledge base is so limited and scattered are each related to a different piece of the puzzle: inputs, process, and outcomes. The first reason is an overemphasis on access as a key objective of technology policies in education. The second reason derives from the methodological challenges that the investigation of the teaching and learning processes poses, in particular in relation to the role that technology plays in the improvement of student outcomes. The final reason is the poor understanding of what the issue about the effects of technology in education really is and how to address it.

Inputs: An overemphasis on access

In many respects, the public discourse about technology policies in education seems to be stuck back in the mid 1980s. Then the key policy goal was to grant access to emerging technologies (computers); at that time, very few students had a computer at home. Thus introducing computers into the classroom was seen as an efficient strategy to cope with the digital divide between the haves and the haves not. Although in many developed countries this policy goal does not apply because of the high level of technology equipment in homes, the public discourse still seems to privilege investments in equipment and connectivity as an appropriate way to modernize schools.

Certainly, there are policy advantages in this overemphasis on granting access to technology in schools. One is that the required investments have a high visibility: equipment shines—even if it is actually used only marginally, if at all. Taxpayers can easily see how public money translates into real investments. On the other hand, technology equipment also has also a symbolic value over other possible investments in education: equipment talks, because it conveys the promise of modernization and symbolizes the commitment of public authorities to support quality education.

Back in the mid 1980s it made a lot of sense to set benchmarking indicators about access to technology in schools, because that was in line with the policy priorities at that time. This resulted in a focus on clearing data about the ratios of students per computer and, more recently, about the percentage of schools connected to broadband Internet. In fact, two complementary indicators are used: the number of devices or services that have been installed (inputs) and the ratio of students per each of these devices—which is, in fact, how far the existing indicators about educational technology can go in terms of process. As an example, Figure 1 presents the latest available data (2009) about the progress made in terms of access to computers in schools by reflecting the evolution of the ratios of computers per student between years 2000 and 2009.

No doubt, in most developed countries the ratios have improved, sometimes dramatically, in just nine years. However, the significance of such a measurement becomes problematic because, lacking other indicators, access becomes overemphasized. Implicitly, the overemphasis on these measurements sends the public message that reducing ratios is a relevant policy concern—regardless of whether the effects of such a reduction on student outcomes are barely correlated, if not entirely unknown. The current problem with this overemphasis on access is that it diverts attention from the core issue: the intensity and variety of uses of technology for enhancing the quality of learning.

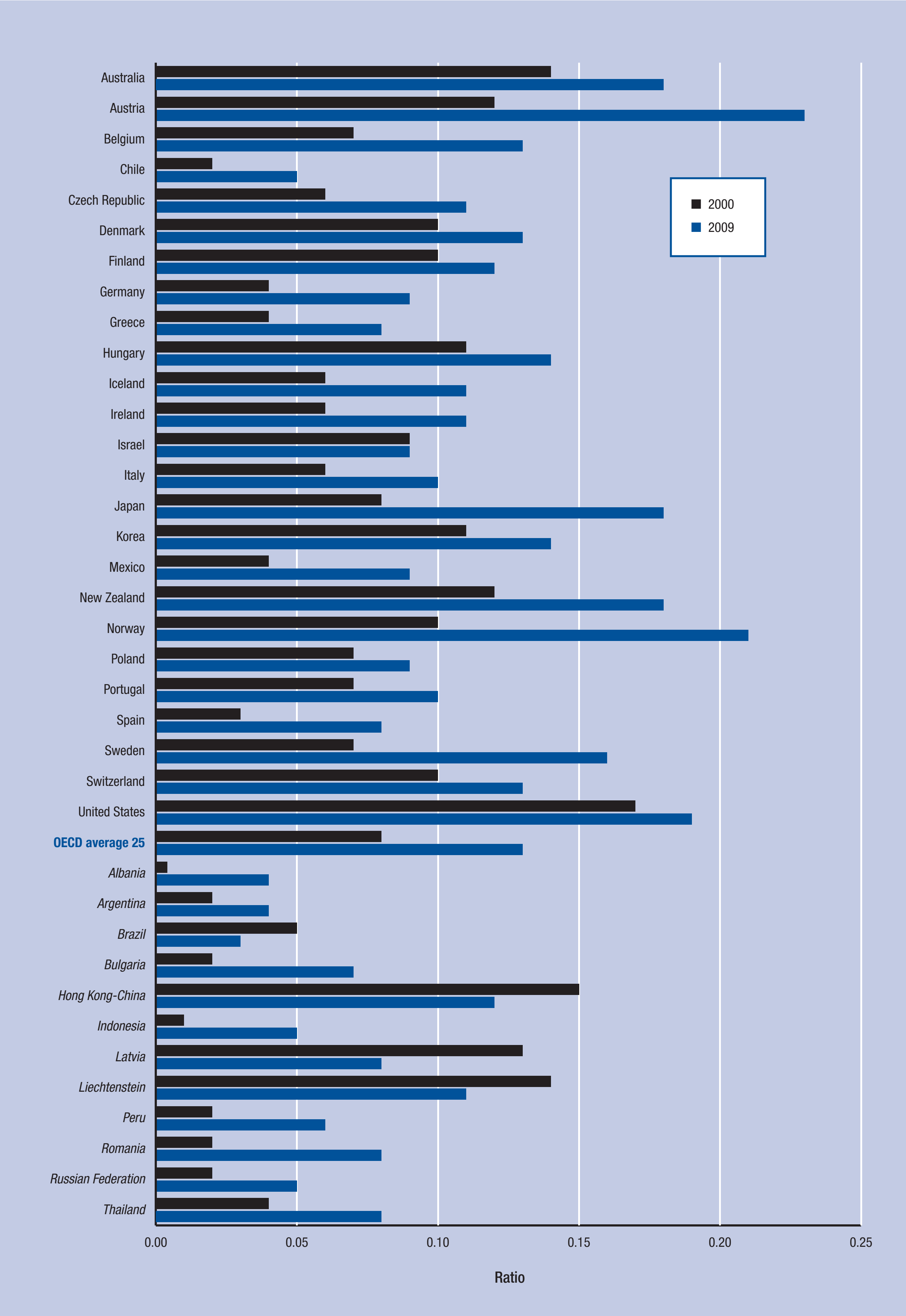
Process: The unaddressed challenge of investigating the role of educational technology

In the context of providing public services, school education is very unusual because it is strongly dependent on the professional decisions made by the teaching professionals, quite often taken individually in the context of a particular classroom and a given subject matter. Obviously, the quality of the educational system cannot be higher than the quality of its teaching body. Yet, in education, policies modify the conditions under which teachers operate, but they hardly modify the nature of the processes involved—that is, teaching and learning. In this context, technology policies have mostly tried to open a window of opportunity for teachers to become more efficient and eventually transform the processes for which they are responsible. But the final responsibility of technology adoption has always been, and will continue to be, in the hands of each individual teacher. This is why technology policies have tended to focus solely on providing access to technology opportunities, assuming that every individual teacher would benefit from this opportunity in the most professionally sound way.

Interestingly, this leads to another important issue that goes beyond technology policies: the governance of school education, particularly when it comes to the issues driving teaching practices. In most countries, the education sector still lacks the kind of evaluation, support, and incentive arrangements that are already found in other areas of public service. How, in the absence of professional evaluation systems, teachers can get their professional development needs duly identified; can be provided with adequate tailored support; and, finally, can be rewarded for good practices remain questions open to policy debate internationally. The problems encountered in relation to how teachers' technology adoption can be driven, monitored, and supported is an indication of the current weakness in policy and governance arrangements in the education sector.

There are also technical issues related to measurement. To begin with, it is worth considering that there are no well-established monitoring systems of teaching and learning practices. In other words, when it comes to analyzing predominant classroom practices, most educational systems are totally blind. What is even more important is that this missing information puts a severe constraint on the ability of educational systems to link practices with student outcomes. Clearly, this lack of monitoring arrangements also sets the current limits on what is known in relation to classroom practices with

Figure 1: Computers-per-student ratios, 2000 and 2009



Source: OECD, 2011.
Notes: OECD average 25 is the average value for the non-OECD participating countries in this survey. Names of partner countries are italicized.

technology—to put it simply, these practices are not monitored at all.

The issue of measurement has a second aspect: the specific difficulties linked to monitoring technology use. Measuring access to technology is far easier than measuring its use, in every sector. In addition, the way in which access is measured in education has nothing to do with the intensity of access, but rather it is linked to the availability of resources—in particular computers and Internet connections—to grant teachers and students opportunities to use technology, whether these opportunities are realized or not. Measured this way, technology use seems to be equivalent again to technology provision but, as a very well known essay on this issue recalled some years ago,[13] it may well be that equipment is oversold and underused, resulting in the paradox of high access but null significant use. An initial indication of this can be seen in Figure 2, which shows the time spent using computers in language-of-instruction lessons, as declared by 15-year-olds in PISA.

The effects: Rephrasing the question

In the domain of technology policies in education, a very simple question is quite often posed: does technology-supported education make a difference? Or, more generally, does technology lead to better student results? When looking for a response in the existing knowledge base about the effects of technology in education, a striking fact seems to emerge: there is no conclusive evidence. This has been known for some years as the "non-significance phenomenon,"[14] leading to the overall conclusion that, in education, technology makes no difference because the investments made have not translated into improved educational productivity,[15] thus reasserting Solow's productivity paradox in the education sector.[16]

Although it appears that the answer to such a question (whether technology improves students' results or not) is quite intuitive, the problem is that the question is neither logical nor useful because it is not formulated in a way that takes into account the complexity of education. Additionally, and more importantly, it does not help to inform policy decisions in an appropriate way, leaving unanswered the issue of whether the investments in technology are worth the effort. Briefly, when phrased this way, without caution, the issue leads to confusion because it is ill-defined or, at least, not sufficiently defined for a proper empirical assessment.

Behind all this ambiguity is a poor understanding between those who make the decisions about investments and those who are expected to benefit from them, because two different rationales are quite often in place. The former would like to receive a clear-cut response about whether or not the investments in educational technology pay off. For the decision makers, these investments are one possible option among many. Teacher training, career incentives, salary increases, or a decrease in class size are just some of the alternative options for educational investments that policymakers can use to improve the quality of education. To make informed decisions, policymakers need cost-effectiveness analysis—although their final decisions could also take into account other factors, such as the symbolic value of the proposed policy. For them, the issue is straightforward: is it worth investing in educational technology?

Teachers and educationalists look at the issue very differently. They usually insist on the complexity of education—that is, on the fact that learning is not only a function of formal teaching activities that take place in the classroom but also of other, nonformal educational influences that can hardly be accounted for in the productivity equation of school education. Activities undertaken by the learner outside school—and even inside school—at home or with peers interact with those carried out during formal instruction hours. As a result, when learning results are measured—as in the context of national or international student assessments—it is almost impossible to isolate the role played by one individual teacher in one specific subject matter during one particular academic year.[17] For the same reason, it is also impossible to isolate the effects of the technology components in learning from the most important factor: the strategies put in place.[18]

Therefore, the issue about the effects of technology in education has to be rephrased in a way that takes into account the complexity of the intervening factors in learning. The real question is not about whether to use technology or not, but about teaching and learning strategies and the ways in which technology solutions can make them more efficient. The problem is that no data are available to address this question comprehensively as of yet.

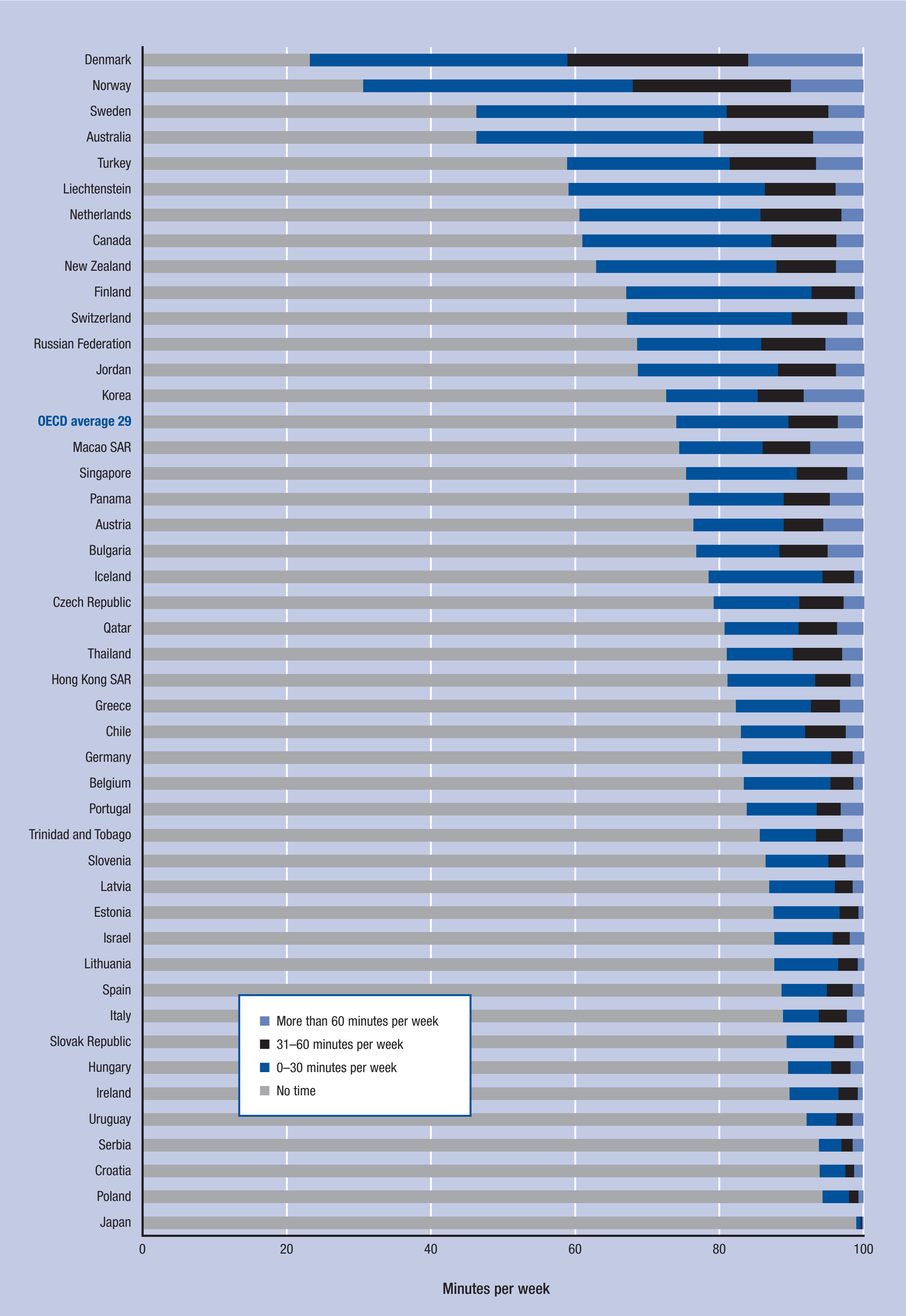
DATA MUST INFORM POLICYMAKING

Despite the limitations of the existing knowledge base, there is no particular argument against a functional approach—one that considers inputs, processes, outputs, and context—in the assessment of technology policies in education. This simple approach provides a clear way to address the key questions, although it has been challenged by competing perspectives.[19] Yet, as it can be seen below, these questions remain mostly unaddressed.

Inputs

The key questions about the inputs of technology policies in education include three different domains: (1) the nature of the technologies proposed and their range (how many different solutions are being backed), (2) the relative financial effort made to support them, and (3) the equitability of access to technology inputs. More specifically:

Figure 2: Intensity of computer use during language-of-instruction lessons



Source: OECD, 2011.
Notes: OECD average 29 is the average value for the non-OECD participating countries in this survey.

1. *What is the nature and range of educational technologies put into the hands of users?* Despite the fact that most literature still refers only to computers, there are competing technology solutions, some of which (such as interactive whiteboards) are more appropriate for teachers, while others (such as tablets) are more suitable for learners. Data about the nature and range of these solutions would help to understand better what type of educational models are being proposed—whether, for instance, they privilege teaching technologies (like interactive whiteboards) or learning technologies (as in one-to-one computing initiatives).

2. *What is the relative size of the investment in educational technology?* The answer to this question should provide key data about the investment in educational technology per user, distinguishing between technology for teacher and for student use. In addition, the resulting data could be compared with other important indicators, such as average teachers' salaries, to provide relevant information about the relative effort made and the comparative importance attached to educational technology.

3. *How equitable is access to educational technology?* The issue of the digital divide is still relevant in most countries, although inequity of access is higher in developing countries. In this particular domain, variance across schools and territories can give an indication of equity of access, which may be linked to poorly designed technology policies (which can neglect the realities facing the teachers, in some cases), or to technology limitations (such as weak networks).

Process

Questions about processes point to a lack of clarity about the purpose of educational technology and thus an ambiguity in its role in teaching and learning. This is far more difficult to measure than the inputs, because a single technology device or service permits multiple uses. Moreover, any attempt to unveil the role that technology plays in teaching and learning would require a degree of transparence in what is going on inside the classroom that currently either does not exist or cannot easily be accepted by the teaching profession. This poses a methodological challenge: how to address the issue of how little is known about the teaching and learning processes. Although the challenge is currently on the agenda of major international assessment efforts, it will take a long time to obtain a clear picture of what teachers and students actually do in the classroom. In the best-case scenario, the areas to be covered are the following:

1. *For what purposes are the different technology solutions being used?* This is commonly known as the issue of the variety of ways that technology can be used. Addressing it must take into account not only different subject areas but also different ages and educational levels of students. Again, it is important to distinguish between uses of technology by teachers and uses by students. In both cases, different technology solutions can be adopted inside the classroom and outside it—for instance, one solution may be used to prepare lessons and a different solution used for doing homework. Thus a comprehensive approach that considers what the user of the technology does in different and multiple settings is needed.

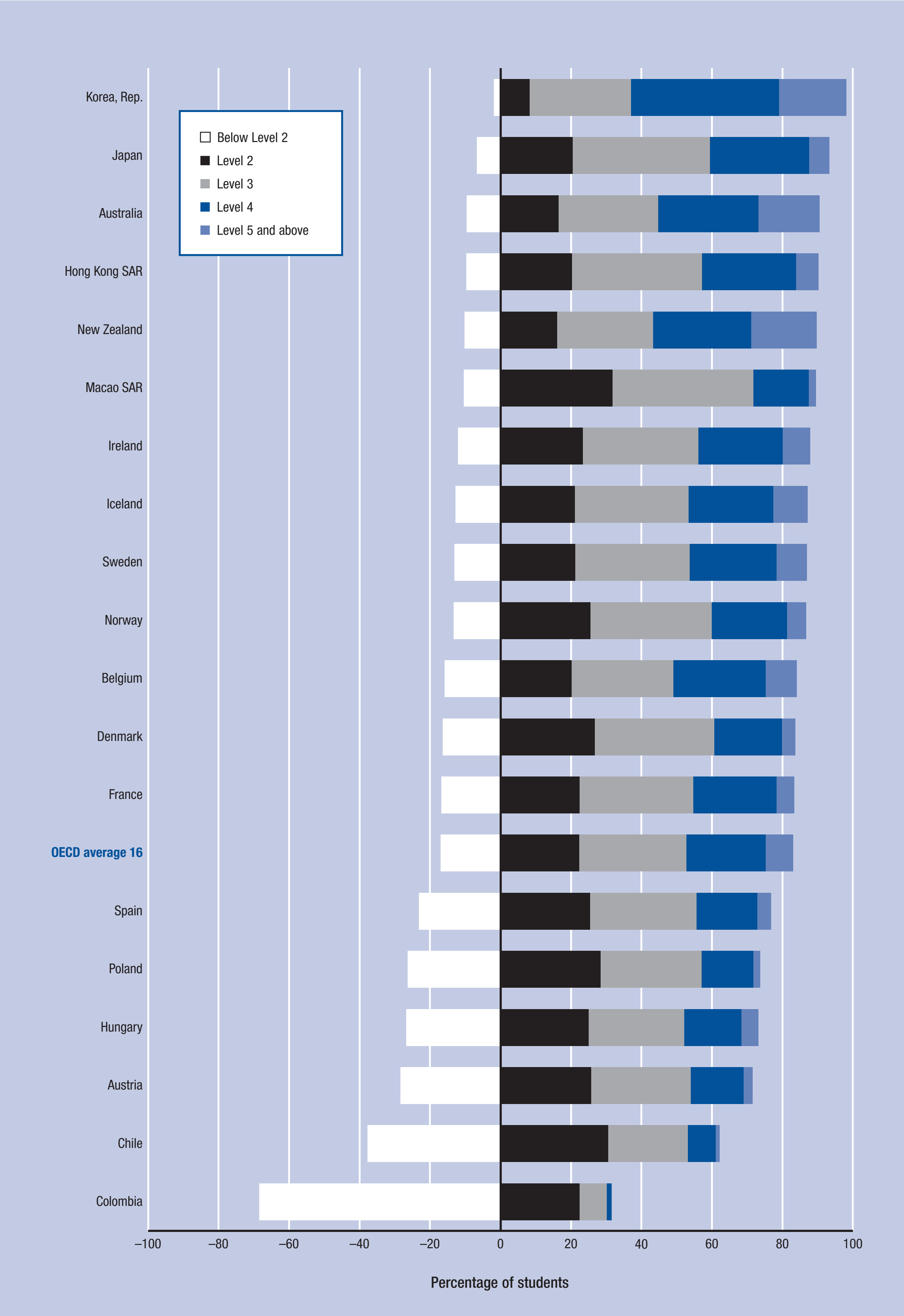
2. *How long is each technology solution being used?* This second question relates to the intensity of the use of technology. As for the previous question, it is important to address this by considering different intervening factors: the type of technology, its purpose, the subject area, the type of user (teacher or student), the educational level, and the location in which it is used. Although some international surveys provide initial indications, existing measures of the intensity of use are left to the individual user and, as it has been already seen, teachers and students tend to have very different perceptions.

Effects on outcomes

To establish a comprehensive approach to the effects of technology in education, two important elements are missing. The first missing factor is a knowledge base about how technology is actually being used in the classroom, which in turn points to the need for a better understanding of the two key variables of intensity and variety of uses. The second missing element is an exploration of the learning outcomes that, going beyond traditional subject areas, are more closely related to technology; these are widely known as "21st-century skills." This is quite often seen as the million dollar question: which technology policies contribute most to the quality of education? Which uses of technology boost student performance in the different subject domains? Given the endless array of possible combinations of teaching and learning strategies, the only way to operationalize this question is to look at the relationships between variety and intensity of uses, on the one hand, and variations in outcomes, on the other.[20]

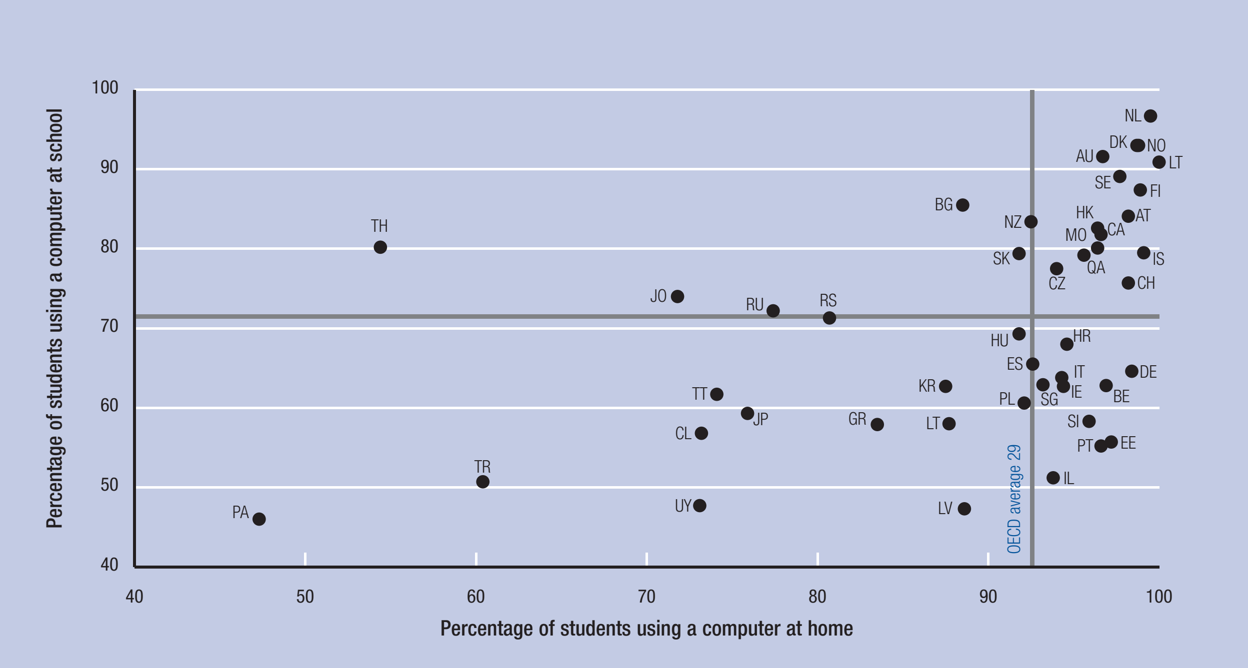
To know more about the contribution of technology to the improvement of learning results, it is necessary to expand the knowledge base about teaching and learning at large—that is, to discover what is going on inside the classroom. A better understanding of the strategies that are currently used in the classroom would not only be informative about the intensity and the variety of uses of technology, but would also be crucial for understanding what works in light of student outcomes and determining the added-value, if any, that educational technology brings to teaching and learning both in the classroom and outside it. Therefore, going further than the mere issue of access, there are clearly two areas for which more information is needed: the intensity and the variety of educational technology usage in the classroom. The

Figure 3: Proficiency of 15-year-olds in digital reading, 2009



Source: OECD, 2011.
Note: OECD average 16 is the average value for the non-OECD participating countries in this survey.

Figure 4: Percentage of 15-year-olds who reported using a computer at home and at school, 2009



Source: OECD, 2011.

Note: OECD average 29 is the average value for the non-OECD participating countries in this survey. Each economy is identified by the two-letter abbreviation used for Internet top-level domain names, available http://www.greenbuilder.com/general/countries.html: AT = Austria, AU = Australia, BE = Belgium, BG = Bulgaria, CA = Canada, CH = Switzerland, CL = Chile, CZ = Czech Republic, DE = Germany, DK = Denmark, EE = Estonia, ES = Spain, FI = Finland, GR = Greece, HK = Hong Kong SAR, HR = Croatia, HU = Hungary, IE = Ireland, IL = Israel, IS = Iceland, IT = Italy, JO = Jordan, JP = Japan, KR = Korea, Rep., LI = Lichtenstein, LT = Lithuania, LV = Latvia, MO = Macao SAR, NL = Netherlands, NO = Norway, NZ = New Zealand, PA = Panama, PT = Portugal, QA = Qatar, RS = Serbia, RU = Russian Federation, SE = Sweden, SG = Singapore, SI = Slovenia, SK = Slovak Republic, TH = Thailand, TR = Turkey, TT = Trinidad and Tobago, and UY = Uruguay.

intensity of use refers to the amount of time and the sequence of use—that is, how much a particular technology solution is being used, either by the teacher or by individual students. The *variety of use,* in turn, is related to the vast array of uses that a particular technology device or service allows—again, either in the hands of the teacher or the student.

An exploration of the outcomes also requires addressing the growing number of calls for a wider approach to skills formation for the knowledge economy and society. These calls insist on the need to include those 21st-century skills in national and international student assessments. Although an international consensus about what these skills are or how to assess them adequately is not yet in place,[21] what emerges from the ongoing discussions is that many, but not all, of these new skills can be duly trained and assessed only through an intensive use of technology solutions. This in turn provides an opportunity to assess the actual benefits to be obtained by using technology in education. A good example of the relevance of this type of assessment is given in Figure 3, which presents the results of the first assessment of student outcomes in digital reading.[22]

To sum up, the evaluating the interaction among processes and outcomes should take into account two different types of outcomes:

1. outcomes in traditional subject areas or skill domains, such as literacy, mathematics, and science, which are those most often assessed in national and international student assessments; and
2. outcomes in new skill domains, such as those often considered to be part of the set of 21st-century skills—these include digital literacy as well as other skills whose execution can be either supported or enhanced by technology.

In addition, it is in outcomes that the complex issue of equity has to be examined, by focusing on the weight of key variables such as gender, socioeconomic status, and location in determining what outcomes are actually achieved.

Context

The investigation of contextual factors is critical to an understanding of the reasons that particular technology solutions receive more financial support, are more widely used across the board, or are more closely linked to better student outcomes. As in other policy sectors, the range of contextual variables can be overwhelming and the right choice can be made only on the basis of a sound theory about educational technology use. A good example of the importance of contextual variables is offered in Figure 4, which presents the percentage of

15-year-olds with access to a computer both at home and at school. Clearly, the gap between the two uses (at home and in the classroom) is far from being constant across countries, thus indicating that intervening variables do matter more than contextual pressure.[23]

The analysis of the contextual variables should consider three different layers:

1. *The micro level:* This level looks at the classroom and, in particular, the individual characteristics of teachers and students, including attachment to technology and views about teaching and learning.
2. *The meso level:* This level considers the school and, more specifically, the institutional policies concerned with educational technology, including technical and educational support arrangements.
3. *The macro level:* This level takes into account the technology policies in the education sector, as supported and enforced by the corresponding public authority at the system level.

METHODOLOGICAL APPROACHES AND CHALLENGES

There is no doubt that data gaps remain unaddressed because of the serious methodological challenges and the scale of the efforts required to address them. Rather than dedicated questionnaires to ministries, which can answer only questions about investments and access, what may work best is a mixed-methods approach that combines empirical experiments, large-scale surveys, and direct observations.

The challenges ahead

In the investigation of technology policies in education with a focus on their effects, three methodological challenges are particularly demanding. These are (1) the way in which teachers make decisions about the role attached to technology in their teaching and learning strategies; (2) the differences present across disciplines and subject areas; and (3) the growing opportunities to use technology from which students benefit outside the classroom.

First, it is essential that the professional decisions a teacher makes about teaching and learning strategies do not consider technology components in an isolated way.[24] Teachers, in light of their assumptions, professional judgments, and available resources make choices in the context of what can be considered to be a constellation of technological opportunities, with a wide range of possibilities that can include the blackboard and printed books and workbooks as well as interactive whiteboards, teacher computers or student laptops, and tablets or portable devices. Teachers do not consider decisions about what particular technology suits them more as if one technology option excluded the rest; instead, they consider which technology solutions (that is, what particular combinations of resources and tools) best suit their teaching and learning strategies for a given purpose.

Second, both intensity and variety of use have to be examined specifically for different subject areas (language, mathematics, science, foreign languages, social sciences, etc.) because the disciplinary cultures as well as the particular learning objectives set for each area require different teaching and learning strategies. Accordingly, it may be expected that different educational technology approaches will also emerge in each subject area.

And third, in yet another important challenge for education, the issue of how today's students relate to digital devices and services in their daily lives and how much they rely on them for information and communication has to be addressed. Young people play an important prescribing role when it comes to families' propensity to buy technological devices or services, as it can be seen in the difference in the percentage of homes with children that have Internet access and those homes without children that have Internet access. On the other hand, children—adolescents in particular—tend to use technology solutions that suit their socialization needs, leading to high levels of technology attachment. Although some experts are convinced that this reliance immediately translates into higher student expectations of technology use in the classroom—a claim that research has not yet been able to support—students do use technology solutions to address their learning needs at home. Typically, they benefit from computers to do their homework and from the Internet to download resources and communicate with peers—partially, but not only, about homework. Clearly, the particular way in which students benefit from technology solutions to learn outside the classroom has to be considered when trying to ascertain the effects of technology on student outcomes.

A mixed-methods approach

There is no doubt that a winning methodological strategy to analyze the effects of technology in education will have to be a mixed-methods approach. Although questionnaires addressed to ministries can work relatively well in centralized systems to investigate the scale of the investments or the state of access, they hardly can be of any use when a more comprehensive perspective, including processes and outcomes, is envisaged or when technology policies in education are decentralized—particularly if the competent authority is each individual school, as seems increasingly to be the case. Empirical experiments, large-scale surveys, and direct observations can be used to address different research questions and, if appropriately combined, result in a holistic approach.

Empirical experiments serve the purpose of investigating which technology solutions result in better learning outcomes while keeping other intervening factors constant. Yet they pose the challenge of how to reach a critical mass of evidence from which clear messages can emerge, which is not yet possible. As has been repeatedly shown,[25] different attempts to conduct meta-analysis provide inconclusive, if not confusing, messages. This is probably because existing experiments have taken a piecemeal approach, using alternative theories that can hardly be combined into one theoretical body and focusing on small-scale and very specific interventions.[26] National and international efforts should be made to reach scientific consensus about the lessons learned and the way forward.

Large-scale surveys, both national and international, can provide basic data about the intensity and variety of uses of technology, although these also have important drawbacks. The most important problem with these surveys is that the perspectives of teachers and students have to be combined to obtain a balanced picture. Teachers, on the one hand, may be tempted to provide socially appropriate responses that suit the taste of the public authority on which they depend, possibly overstating the use of technology. Students, on the other hand, may not be qualified enough—because of their age and their lack of wide experience and mature judgment and expression—to properly qualify either the intensity or the variety of uses: hence the problems with surveys of primary school children. However, surveys have an important role to play in determining how and for what purpose technology is being used at the system level, as well as the internal variance present across territories, schools, or subject areas. If, instead of questionnaires dedicated to technology usage, student outcomes assessment surveys were used, then the resulting knowledge base could be boosted by linking outcomes to intervening factors and thus setting the foundations for a general theory.[27] Ideally, to properly address the issue of the effects of technology, student assessments should provide data about performance both in traditional subject matters and in the more specific domain of the digital skills.

And finally, direct observations are quite complicated methodological exercises that frequently bring up questions about intrusiveness or fake behaviors. However, such observations are the only way to understand the dynamics of technology use in the classroom. They are essential for understanding the reasons behind teachers' professional choices, which would otherwise remain incomprehensible, as well as for knowing the rationale for students' preferences in detail. Ultimately, direct observations can result in a wide array of assessments of what works.[28] When well documented, they facilitate the identification of the key factors to consider when replicating successful experiments and scaling up the lessons learned, thus setting the pace for true systemic innovation.[29]

CONCLUDING REMARKS: HOW ARE TECHNOLOGY POLICIES IN EDUCATION MONITORED AND EVALUATED?

In the context of the issues just discussed, it is easy to conclude that technology policies in education are far from being based on evidence. The limited scope and scarcity of the existing knowledge base would certainly support this conclusion. Moreover, in the absence of a robust knowledge base and appropriate monitoring and evaluation arrangements, there is no way to inform policymaking with empirical evidence. As the title of this chapter suggests, policymakers may be trusting an unknown. However, they may be doing it for a reason: by prioritizing access to technology they convey a very simple message—that they are using taxpayers' money to modernize schools in a way that can be actually seen and touched. What use schools and teachers make of this modernization opportunity it is a different issue that can be addressed only if more powerful accountability systems are in place.

Hopeful indications point to a transition initiated less than two decades ago with the emergence of national and international student assessments. When it comes to an analysis of the effects of technology in education, these large assessment efforts should be seen as a window of opportunity for investigating further the role that technology solutions play in improving the quality of education. But the right research questions must be asked. Because educational phenomena are quite complex and multi-faceted, the right questions are not about whether or not to use technology at all, but about which technology solutions can best suit the evolving learning requirements that each individual teacher has to manage in the classroom. Equipment may shine and speak for itself, but unless it is properly used no educational effects will be ever seen.

NOTES

1 In this document, a reference to *educational technology* is meant to encompass all kinds of digital devices, services, and applications that can be used in a school context, either by teachers or by students. Yet, from a historical perspective, the first public investments aimed at modernizing the tools at the service of teaching and learning can be said to have started in the mid 1950s with large-scale rollouts of school equipments for radio and television.

2 Unless otherwise stated, all the considerations made here refer to primary and lower secondary education only. The context and characteristics of vocational or higher education would require a different approach.

3 Benavides and Pedró 2007.

4 Among other things, this is because the costs of the devices are roughly comparable worldwide but teachers' salaries are not. The ratio between the cost of a laptop computer and the monthly salary of a primary school teacher tends to be higher than 1 in many low-income countries.

5 Pedró 2011.

6 These are commonly referred to as *21st-century skills.*

7 The UNESCO Institute of Statistics (UIS) publishes in cooperation with the World Education Indicators. Other international organizations, in particular the OECD, publish their own analysis based on the same analytical framework, under the series title of *Education at a Glance*.

8 This is particularly evident since PISA's inclusion of assessment of digital skills, such as on-screen reading. See OECD 2011. The International Computer and Information Literacy study (ICILS) is a study that will provide a more comprehensive assessment of digital skills in the coming years. See also the International Association for the Evaluation of Student Achievement, http://www.iea.nl/.

9 The PISA information about these issues is based only on the declarations of students and head teachers.

10 For instance, no information about the use of interactive whiteboards is available, nor is information about teacher practices with technology.

11 OECD 2010a; Scheuermann et al. 2009.

12 Trucano 2005.

13 Cuban 2001.

14 This expression was first used to indicate that, in the particular case of distance education, research was unable to demonstrate the superiority of technology-supported courses over traditional arrangements of distance education. It has been later extended to all other areas of education. See Russell 1999.

15 Brynjolfsson 1993; Hikmet et al. 2008; Peslak 2005.

16 Triplett 1999.

17 However, different techniques related to the measurement of added value aim at improving the chances of isolating influences.

18 Technology components include both traditional (such as paper and pencil) and digital.

19 Some of these perspectives, representing the views of different international organizations—such as the OECD, the European Commission, or the Inter-American Development Bank—are discussed in Scheuermann et al. 2009.

20 This process assumes that all other variables remained constant.

21 Ananiadou and Claro 2010.

22 No international assessments on other digital skills are available as of yet.

23 This is the argument often claimed by proponents of the "digital natives" discourse. See Prensky 2001a, 2001b.

24 Frank et al. 2004.

25 Olofsson et al. 2011.

26 Ross et al. 2010.

27 This has been the case for developing models of technology acceptance that have been successfully texted empirically in the education sector; see Davis et al. 1989; Schwarz and Chin 2007; Venkatesh et al. 2007.

28 Nachmias 2004.

29 OECD 2010b.

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