



Are the New Millennium Learners Making the Grade?

TECHNOLOGY USE AND EDUCATIONAL PERFORMANCE IN PISA



Centre for Educational Research and Innovation

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Foreword

Our increasingly technology-rich world raises new possibilities and new concerns for education. First, technology can provide tools for improving the teaching and learning process, thereby opening new opportunities and avenues. In particular, it can enhance the customisation of the educational process by adapting it to the particular needs of the student. Second, as education prepares students for adult life, it must provide them with the skills they need to participate in a society that increasingly requires technology-related competences. The development of these competences, which are part of the set of the so-called *21st century competences*, is becoming an integral part of the goals of compulsory education. Finally, in a knowledge economy driven by technology, people who do not master these competences may suffer from a new form of digital divide that may affect their capacity to fully participate in the knowledge economy and society.

OECD countries have undertaken significant investments to enhance the role of technology in education. The question that arises is whether this investment in technology in education systems is fulfilling expectations. PISA (Programme for International Student Assessment) 2006 provides a wealth of comparative data to start answering this question. These data provide evidence on the availability and use of technology and the actual benefits accruing from it. Analysis of the data can also help to identify potential bottlenecks, such as low intensity of use in schools, that may hinder the achievement of the desired goals and therefore be of use for policy formulation.

One of the most striking findings of this study is that the digital divide in education goes beyond the issue of access to technology. A second digital divide separates those with the competences and skills to benefit from computer use from those who do not. These competences and skills are closely linked to students' economic, cultural and social capital. This has important implications for policy and practice. Governments should clearly convey that computer use matters for the education of young people, and they should do their best to engage teachers and schools in raising the frequency of computer use to a relevant level. Such an increase would not only be a clear indication of teachers' and schools' implication in the development of 21st century skills

and competences, it would also lead to gains in educational performance. Schools should be made aware of their crucial role in the development of the cultural capital that will allow students to bridge this second digital divide.

This study was carried out under the umbrella of the OECD's New Millennium Learners project. Its objectives include the investigation of the impact of technology use on educational performance. The work presented here updates the findings of a previous OECD report (*Are Students Ready for a Technology-Rich World: What PISA Studies Tell Us*, 2005), and also seeks to delve more deeply into the determinants of technology use, in terms of frequency and purpose, and into the impact on educational performance. It is important to acknowledge that this report is the result of co-operation between two OECD directorates – Education and Science, Technology and Industry (STI) – with support from the Norwegian Ministry of Education through the Network for IT Research and Competence in Education (ITU, University of Oslo). This co-operation has been extremely fruitful and is expected to continue.

Francesc Pedró, from the OECD Centre for Educational Research and Innovation (CERI), managed the report and drafted the chapters on the policy debate about technology in education, the conclusions and policy implications, and the pending agenda. Beñat Bilbao-Orsorio, also from CERI, ensured editorial co-ordination and supervised the chapters written by external contributors. Chapter 2 was written by Magdalena Claro, currently at the Centre for the Study of Educational Policies and Practices in Santiago, Chile. Chapters 3 and 4, with substantial sections contributed by other authors, also benefited from her initial drafts. Cathrine Tømte, Ove Hatlevik and Geir Ottestad at ITU (University of Oslo, Norway) analysed the gender issue and provided an exploratory overview of emerging student profiles of technology use. Pierre Montagnier and Frédéric Bourassa, from the OECD's STI Directorate, studied the relations between technology use and attitudes towards science. Finally, Vincenzo Spiezia and Colin Lewis-Beck, also from STI, contributed the econometric analysis of the links between technology use and educational performance in Chapter 4. The report benefited from the assistance of Ashley Allen, Cassandra Davis and Therese Walsh.

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This book has...



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Executive summary

Objectives of the report

What is the relationship between technology use and educational performance in science? The OECD PISA (Programme for International Student Assessment) provides a source of evidence for the analysis of this relationship. This report presents the main findings and policy implications of this analysis. This work was carried out under the umbrella of CERI's New Millennium Learners project. The work presented here updates the findings of a previous report (OECD, 2006) and seeks to go deeper into the determinants of technology use, both in frequency and in purpose, and into the impact on educational performance.

This report presents results based on PISA 2006 and continues the work initiated at the OECD in 2005 which presented an initial picture of the role of ICT in education based on PISA 2003 data (OECD, 2006). It continues the investigation of how equitable the access is to computers across countries, how familiar students are with ICT, how often and where they use computers, for how long they have been using them, how confident they feel, for which tasks they use them and, finally, what the relation is between these characteristics and students' performance.

How the report is organised

More precisely, the Introduction presents overall considerations on the PISA 2006 data and establishes the objectives and structure of the report. Chapter 1 summarises the current policy debate on the putative benefits of the use of ICT in education. Chapter 2 presents students' access to ICT, in terms both of infrastructure, *e.g.* computers, Internet connections and computer software, and of the context or conditions in which ICT access takes places, *i.e.* at home or at school or in both. Chapter 3 shows how students use ICT. In this analysis, a profile emerges indicating that 15-year-old students who use ICT are far from a homogeneous group. Also included in this chapter

is a more in-depth analysis of the role that ICT use may play in students' attitudes to science. Chapter 4 examines the relation between students' access to and use of ICT and their performance in PISA 2006. To do so, the current relation between ICT use and student performance is first presented. Then, a more detailed microeconomic analysis explores the possible causality effect of ICT use on students' performance. Chapter 5 draws the main conclusions and makes some policy recommendations that may help improve overall ICT policy in education. A future research agenda identifying crucial data needs is also highlighted. These data could serve to provide more solid evidence on the role and impacts of ICT in education.

Main findings

1. **Today all students in OECD countries are familiar with computers.** On the whole, less than 1% of 15-year-old students in OECD countries declared that they had never used a computer. Interestingly, neither gender nor socio-economic status is an important determinant in this respect.
2. **Frequency of use at home is not paralleled by use at school.** In most OECD countries more than 80% of 15 year-olds use computers frequently at home but a majority do not use them at school, except in Hungary.
3. **Despite increasing investment in ICT infrastructure in schools, student-computer ratios are still a handicap for ICT use in schools.** The OECD average is five students per computer. It has dropped by 50% since 2000, when it was ten students per computer, but it is roughly the same as it was in 2003.
4. **Digital media are increasingly used as educational resources, but disparities across countries are large.** As access to digital media and the Internet at home increases, the importance of books as tools for coursework decreases.
5. **The main use of computers is related to the Internet or to entertainment.** More than 60% of students frequently use their computers for e-mail or chatting (69%) and to look up information about people, things or ideas on the Internet (61%). More than 50% frequently use them to download music (58%) and play games (54%), and the relatively lowest percentage of frequent computer use is to download software (41%) and to collaborate with a group or team (37%).
6. **A variety of student profiles are linked to different uses of technology.** The six suggested profiles (*analogue*, *digi-casual*, *digi-wired*, *digi-sporadic*, *digi-educational*, and *digi-zapper*) reflect a variety

of computer uses which relate to socio-economic status (ESCS) and gender. The strong socio-economic differences in students' use of computers for leisure activities is not matched by similar differences in the type of activities more likely to be practiced in school. In fact, the difference between students from the bottom and top ESCS quarters is twice as large for Internet and entertainment uses as it is for programmes and software uses. This is an important finding because it gives support to the assumption that school use of digital media can help to reduce the digital divide.

7. **ICT familiarity matters for educational performance.** Performance differences associated with the length of time students have been using a computer remain once socio-economic background is accounted for.
8. **There is a stronger correlation between educational performance and frequency of computer use at home than at school.** In a large majority of countries, the benefits of greater computer use tend to be larger at home than at school. In every country, students reporting “rare” or “no use” of computers at home score lower than their counterparts who report frequent use. Clearly, in the case of school use, more computer use does not mean better results in subject-based standardised tests such as PISA 2006.
9. **With the right skills and background, more frequent computer use can lead to better performance.** The analysis of PISA data shows that for educational performance, computer use amplifies a student's academic skills and competences. These competences are closely related to the student's background, and particularly to his/her economic, cultural and social capital. Given the lack of such capital, the benefits from more computer use would be limited.
10. **The first digital divide has faded in schools but a second one is emerging.** In nearly every OECD country, all students attend schools equipped with computers, 88% of which are connected to the Internet. However, there is still a digital gap related to home access. In the light of the results of this study, it can be concluded that the importance of the digital divide in education goes beyond the issue of access to technology. A second form of digital divide has been identified between those who have the necessary competences and skills to benefit from computer use and those who do not. These competences and skills are closely linked to students' economic, cultural and social capital.

Policy implications

1. **Raise awareness among educators, parents and policy makers of the consequences of increasing ICT familiarity.** Policy makers have to consider the educational implications of the changes brought about by technology. First, students need technology and access to digital media for learning purposes which current provision in schools may not adequately meet. More importantly, education standards need to include the kind of skills and competences that can help students become responsible and performing users of technology and to develop the new competences required in today's economy and society which are enhanced by technology, in particular those related to knowledge management. Teachers need a clear policy message in this respect: public recognition that teachers are expected to deal with these competences as a priority in their subject areas or domains. This public recognition will require the inclusion of these competences in national and international assessments. In a number of respects, those responsible for teaching the new millennium learners have to be able to guide them in their educational journey through digital media. Teacher training, both initial and in-service, is crucial for disseminating this key message and for equipping teachers with the required competences. Parents also need to be aware of these changes. In the light of the findings of this study, it is clear that parents have a crucial responsibility to help their children develop a responsible attitude to using digital media in a networked environment. Their influence has to go beyond safety issues to include approaching digital media critically to make the most of them. Public policies can help to raise parental awareness in this respect.
2. **Identify and foster the development of 21st century skills and competences.** Today's labour force needs the skills and competences that are required by a knowledge economy. Most of these are related to knowledge management and include processes related to selection, acquisition, integration, analysis and sharing of knowledge in socially networked environments. Not surprisingly, most of these competences, if not all, are either supported or enhanced by ICT. For young people, schools are the only place where such competences and skills can be gained. Accordingly, governments should make an effort to identify and conceptualise the required set of skills and competences so as to incorporate them into the educational standards that every student should be able to meet by the end of compulsory schooling. Two requirements must be fulfilled. First, participation of both economic and social institutions, ranging from companies to higher education institutions, is critical. Second, this set of skills and

competences must become the core of what teachers and schools care about. This will only be achieved by incorporating them into national education standards that are enforced and assessed by governments.

3. **Address the second digital divide.** Computer use can make a difference in educational performance if the student has the appropriate set of competences, skills and attitudes. This is another powerful reason for governments to engage in the identification of the 21st century skills and competences, and for teachers and schools to consider the importance of developing them in order to address this second digital divide. Teachers and schools can make a difference for students who lack the cultural and social capital that will allow them to benefit from the use of digital media in a way that is significant for their educational performance. If teachers and schools fail to acknowledge this second digital divide, and act accordingly, they will reinforce its emergence. It is important to realise that the fact that students appear to be technologically “savvy” does not mean that they have developed the skills and competences that will make them responsible, critical and creative users of technology.
4. **Adopt holistic policy approaches to ICT in education.** Besides public investments, other factors could improve ICT use in schools. An overall favourable environment, the inclusion of ICT in curriculum design or strong leadership and commitment from teachers and headmasters to implement ICT-rich teaching could also significantly influence the use of ICT in schools. As this report shows, one of the limitations of many educational ICT policies is that most countries have not developed holistic policies for the educational use of ICT. The current results suggest the value of critically evaluating current policies and their results in order to develop complementary policies that would maximise the effects of the deployed infrastructure.
5. **Adapt school learning environments as computer ratios improve and digital learning resources increase.** Students should be able to locate and use a computer at any time, according to the particular needs of their individual and team assignments. Although there are indications of innovative developments in this direction everywhere, governments should provide the conditions for them to flourish and should assess their effects. Two areas which deserve particular public policy attention are computer ratios, particularly in the light of the growing trend to introduce 1-to-1 computing arrangements, and the availability of digital learning resources.
6. **Promote greater computer use at school and experimental research on its effects.** An alternative explanation for the lack of correlation between computer use at school and educational performance

is that frequency of use is currently irrelevant. There are positive gains from computer use at home because the frequency of use has reached a critical level. According to the existing evidence, such a level is far from the marginal one a student currently experiences at school. Governments need to create the necessary incentives to engage teachers in the exploration of the benefits of ICT in education. But in so doing they should acknowledge that as responsible professionals teachers are particularly receptive to one powerful incentive: the evidence of what works.

Finally, it should be stressed that data availability remains one of the main handicaps for understanding the role of ICT in education. New data could give a more nuanced picture of the availability and use of ICT and its effects on educational attainment, the quality of the teaching and learning process, and the development of the 21st century competences.

Reference

OECD (2006), *Are Students Ready for a Technology-Rich World? What PISA Studies Tell Us*, OECD Publishing, Paris.

Introduction

An increasingly technology-rich world is bound to have important implications for education. Accordingly, OECD countries have undertaken significant investments to enhance the role of ICT in education. This raises the question of whether investment in ICT for education is fulfilling expectations. PISA 2006 provides a wealth of comparative data to start to answer this question and to shed light on the availability and use of ICT and its benefits. The analysis of these data can also help identify potential bottlenecks that may make it difficult to achieve the desired effects and may, therefore, be of use for policy formulation.

The importance of ICT-supported competences is increasing

As economies move towards more knowledge-intensive, information-rich activities, information and communication technologies (ICT) have become crucial to economic activity in most industrialised countries and an important tool for facilitating innovation and economic growth throughout the economy. It is recognised that extensive ICT use is economically positive, mainly because it reinforces the acceleration of productivity gains. As a result, ICT is gaining in importance in modern economies. According to the European Union, around 20% of current jobs in Europe are in the ICT sector or require ICT, and its importance in the overall European economy has doubled in the last decade to reach 8% of gross domestic product (GDP).

Moreover, societies are evolving rapidly because of ICT, which have facilitated new forms of communication *via* e-mail and SMS, new forms of civil participation through blogs and Internet-based opinion platforms, and new ways to communicate with public administrations.

This increasingly technology-rich world has profound implications for education, and ICT may provide significant educational benefits. First, ICT can provide tools for enriching the teaching and learning process by opening new opportunities and avenues. In particular, ICT can enhance the customisation of the educational process, adapting it to students' particular needs. Second, education's role in preparing students for adult life means that it must provide students with the skills needed in a society in which ICT-related skills and competences are increasingly indispensable. The development of these competences is becoming an integral part of the goals of compulsory education. Finally, in a knowledge economy driven by ICT, people who do not master these competences may suffer from a "digital divide" which can affect their capacity to fully participate in the economy and society. It is the role of education to bridge this divide.

Given these expected benefits, many countries have undertaken significant investments to enhance the role of ICT in education. This raises the question of whether ICT investment in education is fulfilling expectations. PISA 2006 provides a wealth of comparative data to start to answer this question and to shed light on the availability and use of ICT and its benefits. The analysis of these data can also help identify potential bottlenecks that may hinder achievement of the desired effects and may, therefore, be of use for policy formulation.

Methodological approach

This section describes how the sources of information on technology in the PISA database are used and how the data were gathered and outlines the contents of the different chapters of the report.

A reminder of PISA methodology and procedures

In 2006, PISA ran its third triennial survey of 15-year-old students to assess their knowledge and skills. It was conducted in 57 countries, including all 30 OECD member countries and 27 partner countries and economies. It surveyed nationally representative samples of some 20 million 15-year-olds. As in the past, all students of this age were included in the target population regardless of the grade or type of institution they were enrolled in or whether they were enrolled full-time or part-time. As a result, these students have had different educational experiences, both within and outside schools.

PISA assesses the students' performance in mathematics, reading and science, as well as in cross-curricular problem-solving skills. In 2000, the major domain was reading, in 2003 it was mathematics and in 2006 it was science. The total assessment time was 390 minutes, divided into 60-minute tests for reading, mathematics and problem-solving, and 210 minutes for science.

In addition to evaluating student performance, PISA collects valuable contextual data on the characteristics of the students and the institutions in which they study which may explain differences in performance. This information includes data on gender and on socioeconomic background of both students and their parents, the perceptions of schools and of how students learn, and students' motivations as well as their engagement and attitudes.

As on the previous two occasions, PISA 2006 also gave countries the option to administer a short questionnaire on students' familiarity with ICT. This questionnaire made it possible to go into more detail on the subject of student access to computers than the main questionnaire. The ICT questionnaire focused more on how familiar students were with computers than on ICT in general. Students were asked how often they used computers and where and how they learned to use computers and the Internet. They were also asked about how confident they were in performing certain computer tasks. As a result, a more nuanced picture of students' access to, and use of, ICT can be drawn for the 25 OECD countries and 14 partner countries and economies that completed this questionnaire. The full questionnaire is included in Annex D, and it is important to note that it includes the same questions as were used in PISA 2003. CERI did not participate in the development of this questionnaire, but it has provided input for the versions to be used in 2009 and in 2012.

To complement the information on ICT, an additional questionnaire was sent to school principals about the use of ICT in their schools and the extent to which a lack of ICT hinders instruction.

To sum up, PISA collects information on ICT using three different instruments:

- *Student questionnaire:* Students in all participating countries answered a 35-minute questionnaire that focused on their background, learning habits and perceptions of the learning environment, as well as on their engagement and motivation. As part of this questionnaire, students answered questions about whether or not they had a home computer to use for schoolwork, educational software, a link to the Internet and a calculator.
- *School questionnaire:* School principals completed a questionnaire about their school which asked them for information on demographic characteristics as well as for an assessment of the quality of the learning environment at school. As part of this questionnaire, principals provided information on the availability of computers at their schools and on whether or not their schools ran computer clubs for mathematics, as well as on their perceptions of the extent to which a lack of computers, computer software, calculators and audiovisual resources hindered instruction in their school.
- *ICT familiarity questionnaire:* Students in countries that administered the ICT questionnaire took five minutes to complete an ICT familiarity questionnaire regarding their access to and familiarity with ICT. Students provided information on whether or not ICT was available to them, how they used it, how confident they felt performing certain tasks on a computer, and on their general attitude towards using computers. Students also provided information on how they learned to use computers and the Internet.

New approaches and analysis included in this study

This report presents results based on PISA 2006 and continues the work initiated at the OECD in 2005 which presented an initial picture of the role of ICT in education based on PISA 2003 data (OECD, 2006). It continues the investigation of how equitable the access is to computers across countries, how familiar students are with ICT, how often and where they use computers, for how long they have been using them, how confident they feel, for which tasks they use them and, finally, what the relation is between these characteristics and students' performance.

In addition to these very important questions, the current report introduces four new issues:

- **Trends in ICT use and access.** The value of PISA monitoring performance is growing over time, and although it is not yet possible to assess long-term trends, the current report presents the evolution of different countries in terms of ICT access and use whenever possible.
- **Student profiles of ICT use.** Youngsters' ICT use has often been described in terms of stereotypes. The preconceptions of the “gaming boy” and the “communicating girl” are widespread in the population. This report gives a more nuanced picture which will help overcome this oversimplified classification of 15-year-old students.
- **A relation between ICT use and attitudes to science.** ICT use may mould students' attitudes and make them more receptive to, and trigger their interest in, subjects such as science. The relation between ICT use and students' attitudes towards science is explored.
- **Microeconometric study of the role of ICT use on students' performance.** The relation between ICT use and student performance has generally been explored through association analyses which cannot establish causality. In this report, new exploratory research using econometric techniques attempts to shed more light on the actual impact of ICT use on students' educational performance.

The resulting report is organised in five chapters which aim to illuminate: the policy debate on the importance of ICT for education (Chapter 1); students' ICT access (Chapter 2); students' use of ICT (Chapter 3); the relation between ICT use and educational performance (Chapter 4); and policy recommendations arising from the analysed data and the need for further research (Chapter 5).

Reference

OECD (2006), *Are Students Ready for a Technology-Rich World? What PISA Studies Tell Us*, OECD Publishing, Paris.

Chapter 1

The policy debate about technology in education

There have been three main policy expectations regarding technology in education. The first was that schools would equip students with the technical skills required by an increasingly technology-pervaded economy. The second was that schools would bridge the digital divide by providing students with universal access to computers and the Internet during compulsory education. The third was that technology would improve educational productivity by making teaching and learning more effective – improving learning outcomes by changing teaching and learning strategies. In some respects, it would seem that the initial policy expectations have not been fulfilled, but a closer analysis shows the need to reframe them in light of changing societal needs. In particular, the issue of the effects of technology use on educational performance should be reviewed.

Initial expectations about technology use in education under scrutiny

Almost three decades ago, policy makers began to implement policies aimed at deploying technology in schools. At that time schools were seen as the perfect place for students to gain the skills required to cope with what were, at the time, “new” technologies. Soon after, policy makers fully subscribed to the idea that there was enormous potential for technology to transform and modernise school education. For example, of the 51 chief state school officers in the United States, 48 ranked the “use of technology in instruction” as the second most important issue facing public education in 2000 and the most important issue expected to face public education in the year 2020 (Morgan *et al.*, 1998). This called for a double commitment: on the one hand, to provide schools with the tools necessary to equip students with the required skills in a technology-rich world; on the other, to harness what was believed to be a revolutionary potential to bring innovations and dramatic educational changes into classrooms. In addition, as inequalities in access to technology became apparent, schools were expected to bridge this digital divide by granting universal access and training to all students during compulsory education. Accordingly, investments were made first to address infrastructure and material requirements along with in-service teacher training needs and, more recently, to focus on the production and use of digital learning content and the required broadband capability to fully benefit from it.

Although little is known about the size and intensity of the investments made in this domain, there are clear indications that the basic conditions for the creation of a propitious environment for the use of technology in schools have been in place for a long time. By 1999 the limited available data on trends in technology investment and use (technology spending, schools connected to the Internet) showed sharp increases (OECD, 1999). In 2003, more robust data from PISA confirmed exponential growth in the presence of technology in education (OECD, 2006). Between 2000 and 2003 students-per-computer ratios dropped by more than half in most countries and even more in those that were lagging. While less than a third of secondary schools had Internet access in 1995, it was virtually universal by 2001. This is currently the case for broadband connectivity in a growing number of OECD countries.

Yet, at the turn of the century and with the bursting of the Internet bubble, policy makers had to adjust their expectations. As they could not see schools and teachers adopting technology at the desired pace and with the expected intensity or clear-cut evidence of the expected benefits, a certain uneasiness, if not scepticism, began to appear. As a result, in many OECD countries, incorporation of technology in education has lost its status as a policy priority even though, for certain political reasons, investments have not ceased. In many respects, the principle of “build it and they will come” seems to have been

adopted, and education systems keep investing in technology in the belief that, sooner or later, schools and teachers will adopt it and benefit from it.

Nevertheless, many policy makers seem disappointed by what appear to be the unfulfilled promises of technology in education, not only in OECD countries (Benavides and Pedró, 2007). Therefore, it is worth asking what the initial expectations were and whether or not the current disappointment is supported by the evidence.

As mentioned, there were three main initial expectations regarding the incorporation of technology in education. The first was that schools would equip students with the technical skills required by an increasingly technology-pervaded economy. The second was that schools would bridge the digital divide by providing students with universal access to computers and the Internet during compulsory education. The third was that technology would improve educational productivity by making teaching and learning more effective – improving learning outcomes by changing teaching and learning strategies.

First expectation: learning to use technology

The first expectation was based on the assumption that users should learn how to use applications and even languages that, in the early 1980s, were not easy to master or cheap to buy. However, applications increasingly evolved, incorporating user-friendly interfaces, and equipment and application costs decreased enormously, thus paving the way for universal access at home.

Already in 2003 PISA data showed that in most OECD countries a majority of students had acquired the technical skills required to manage computers and the Internet outside of school and without any external support – mostly by trial and error (OECD, 2006). As access to computers at home generalises, most students now possess the basic skills required to manage technological devices such as computers (but also an ever-increasing range of digital devices, ranging from cellular phones to videogame consoles) and the corresponding services and applications. They easily adopt emerging devices and applications that capture their interest or respond well to their needs. The PISA findings presented here clearly support this.

Therefore one of the main expectations is no longer relevant, at least as it was formulated in the early 1980s. Schools are not expected to teach students how to use computers because children learn this by themselves. Accordingly, many policy makers would say that the first expectation was not met by schools but, in many respects, was achieved by a change in the environment.

However, there is a big difference between technically mastering a device or service and using it effectively. When it comes to education, the point is

no longer how to use a computer, but what to use it for. Education, or the lack thereof, can make a big difference when it comes to wise, safe and responsible use of technology. Accordingly, the question of what it means to learn how to use a technology has to be reconsidered.

Second expectation: struggling with the digital divide

The second expectation was that schools would be a means of countering the digital divide. The digital divide was defined as the difference between those who had access to the technology and those who did not. Even if differences in digital access still persist, it is increasingly apparent that in most OECD countries facilities for the use of technology are more pervasive in homes than in schools. In fact, there is evidence that homes with children are more likely to have computers and Internet access than those without (OECD, 2008).

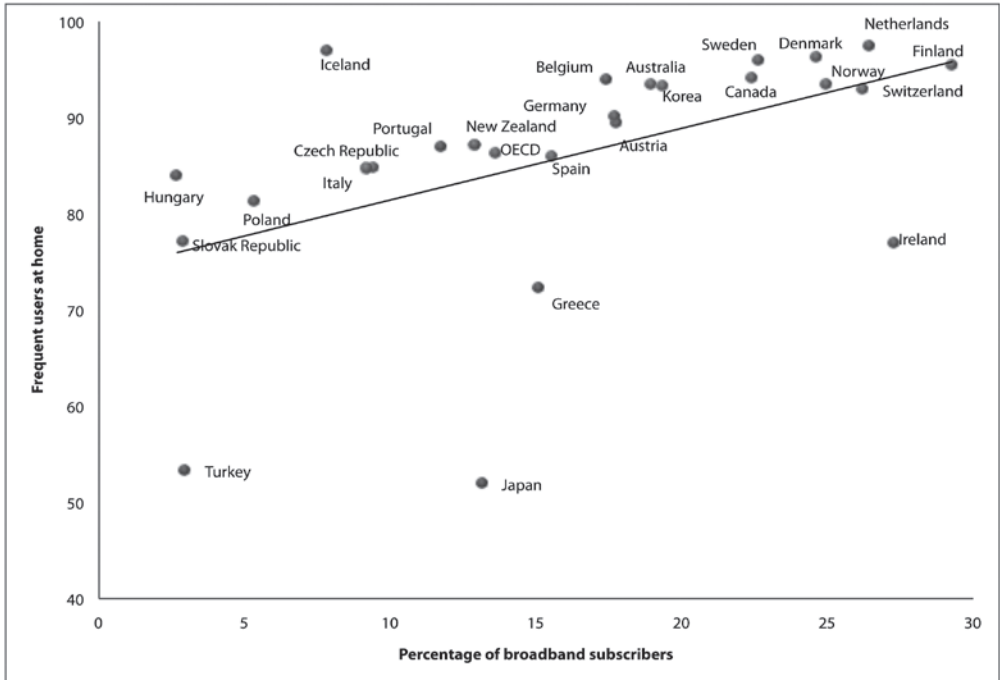
Recent data (included in this report) show that in the short term access to computers may no longer be an issue for most, if not all, 15-year olds in OECD countries. A saturation point, with roughly 100% of students having home access to a computer, is likely to be reached some time in the next decade or even early in the decade in some Nordic countries. However, the access divide still exists for the Internet although it too is decreasing. Youngsters' demand for Internet access, particularly through broadband, is likely to increase in the coming years to allow them to benefit from social and Web 2.0 applications as well as from future developments such as the so-called "Internet of Things".

Figure 1.1 provides an indication of the percentage of 15-year-olds who declare being frequent users of a computer at home. The figure suggests that there is a clear correlation between this percentage and broadband access to the Internet at home in most OECD countries. This is clearly an indication that quality Internet access may be a driver of computer use by 15-year-olds, but also that teenagers may drive adoption of quality Internet access.

In any case, the digital access divide has been narrowing steadily, and schools are no longer seen as the main source of access for the vast majority of students. Even if schools play a role in countries or areas where home access to technology is lagging, they are hardly considered the main means of reducing the digital divide. Instead, technology and market developments, coupled with some government plans, are seen to play that role. However, new forms of the digital divide related to alternative uses of technology may be emerging, and education will be expected to cope with them.

Figure 1.1. **Percentage of homes with broadband subscriptions and of 15-year-olds declaring frequent use of a computer at home**

Selected OECD countries (2006)



StatLink  <http://dx.doi.org/10.1787/811551420826>

Note: Data presented only for OECD countries that used the ICT Familiarity Questionnaire in PISA 2006.

Source: *OECD Information Technology Outlook* (2008) and PISA 2006 Database.

Third expectation: improving educational performance

The third expectation, which involves the efficiency of teaching and learning and the productivity gains attached to technology use in education, is the most problematic of the three. At the outset, it was believed that technology could boost educational performance (Rowe, 1998). Teachers and schools would be able to better manage student records and files and better monitor students' individual progress. Students themselves would benefit directly from technology-supported teaching and learning; this would also significantly improve their educational performance while increasing their engagement, particularly that of low performers (OECD, 1999). In addition, technology would allow room to personalise learning and increase learning opportunities for a vast range of students with special education needs. In

sum, the question was: would the cost of the technology, and the human effort needed to learn to use it effectively, be offset by the increases in educational outputs? (Massy and Wilger, 1998) The expectation was that the investments made in technology would be exceeded by the superior results attained. Technology would pay off.

Formulated in this way, this expectation was well received by the finance authorities – those in a position to commit the necessary investments. In the public interest, the return to such investments should be evaluated against alternative policy options. Although some public accountability of the results obtained would be expected, technology expenditure in education has gone relatively unnoticed and unstudied (Peslak, 2005).

Why is this issue so confusing?

Today policy makers are left with a complex picture which is far from clear, convincing or even inspiring for policy action. It is the result of a number of problematic issues, namely, the lack of relevant data, the low rate of adoption of technology by schools, the myriad of approaches adopted in educational research in this domain, and the conceptualisation of the expected productivity gains.

To begin with, there is a lack of internationally comparable indicators on technology adoption in schools, and those that exist are clearly insufficient or ill-defined. Available indicators focus mostly on access, as measured for instance by the average number of computers per 100 students or the percentage of schools with broadband connectivity. Many of these indicators were created to monitor the expansion of the equipment base and the deployment of infrastructures but, in the absence of other relevant data, some have become problematic. As an example, the most widely used indicator, the ratio of students to computers, does not take into account the age of the equipment, although this would affect possibilities to perform activities such as streaming videos.

Consequently, not only do the indicators for access to technology in schools need to be refined, new ones dealing with processes (such as availability of technical and pedagogical support) and outcomes (such as uses attached to technology or applications or time of use) have to be developed. For the time being, this lack of critical information makes any serious attempt at comparative policy analysis extremely difficult. Whatever policy lessons from peer learning that might eventually result are therefore lost.

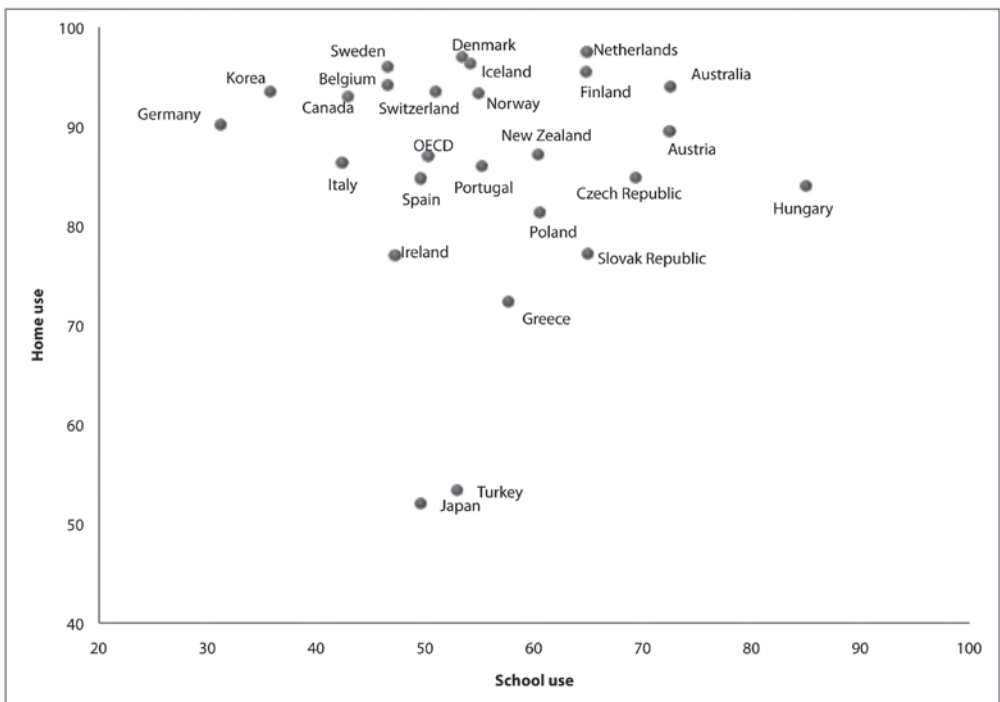
Second, there are clear indications that the pace of technology adoption is slower than expected or, in other words, that the pace of technology adoption by teachers is slower than in other sectors or even at home. It could reasonably be expected that in countries where technology adoption is

faster, schools would follow. Accordingly, in countries where, for instance, a high percentage of 15-year-olds are already frequent users of computers at home, schools would also show high rates of computer use. This is not what Figure 1.2 indicates. It clearly shows that there is no relation between frequent computer use at home and at school by 15-year-olds. Home use does not act as a driver for school use.

From a different perspective, Figure 1.3 demonstrates that the frequency of computer use in lower secondary schools is related neither to the ratio of students to computers, nor to broadband connectivity in schools. In other words, countries' efforts to provide quality Internet access and to increase the availability of computers do not seem related to the frequency of use of computers in schools. Some OECD countries, such as the Nordic countries,

Figure 1.2. Percentage of 15-year-olds declaring frequent use of a computer at home and at school

Selected OECD countries (2006)



StatLink  <http://dx.doi.org/10.1787/811636413673>

Note: Data presented only for OECD countries that used the ICT Familiarity Questionnaire in PISA 2006.

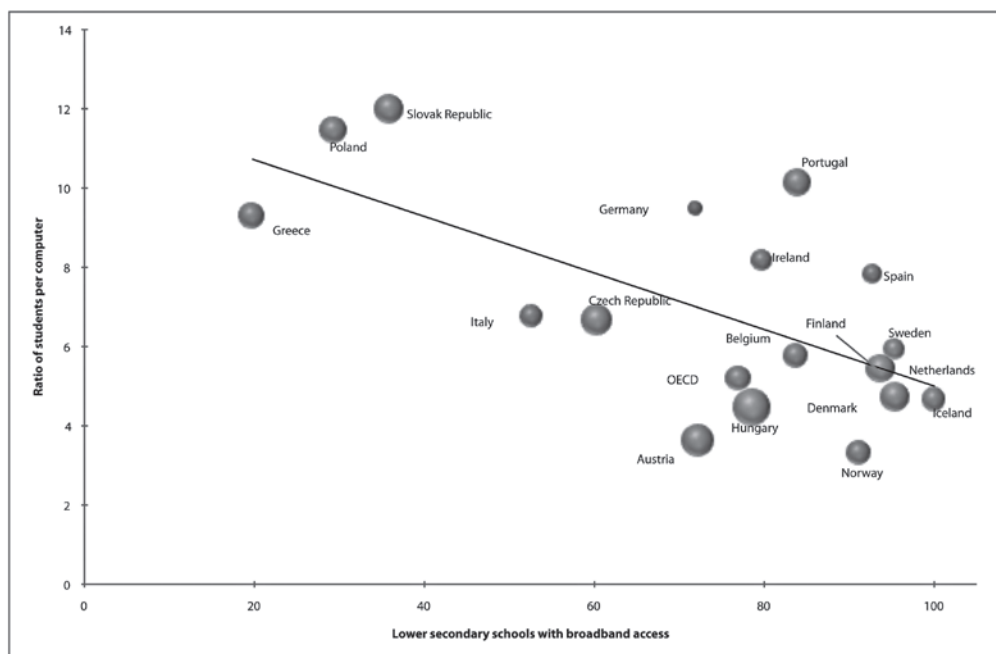
Source: PISA 2006 Database.

have good infrastructure, but this does not imply that frequency of use is higher than in other countries where such conditions are far from being met. The main factor explaining frequency of use is to be found in the professional thinking and motivation of teachers. This is obviously a challenge for teacher training institutions and more precisely for those responsible for initial teacher training. Clearly, the installed base of equipment and connectivity infrastructure in schools remains underutilised.

Under these circumstances there is not much gain in productivity at the system level. To observe significant changes, either in processes or outcomes, a critical threshold of use has to be passed. If, as seems to be the case in European Union countries (Empirica, 2006), the average use of computers in the classroom is around one hour per week, hardly any effect can be expected.

Figure 1.3. Are ratios of students per computer and broadband access drivers of computer use in schools?

Selected OECD countries (2006)



StatLink <http://dx.doi.org/10.1787/811645564682>

Note: Data presented only for OECD countries that used the ICT Familiarity Questionnaire in PISA 2006. The size of the bubbles represents the percentage of 15-year-olds declaring frequent use of computers in their school.

Source: PISA 2006 Database.

This is not to say that there are no impressive developments, but they tend to be discrete, isolated, not scaled up, and without systemic effect. In education, as in many other sectors, technology is expected to act as a driver of innovation. There is in fact a wealth of literature presenting impressive accounts of technology-based innovations in schools and classrooms that seem to work. Many are the result of significant funding efforts by public authorities, foundations or even firms, which are always matched, if not surpassed, by teachers' own efforts. How educational innovations – of which those spurred by technology are one particular case – are monitored, assessed and eventually scaled up seems to be a real issue in most OECD systems. The role of educational research in building a coherent and easily accessible knowledge base about what works in technology in education and why still remains ill-defined. Without the capacity to draw lessons from specific innovations, school systems may be losing serious opportunities to promote technology-supported educational innovation in a systemic way.

Third, educational research has brought to this debate many different approaches and methodologies whose results are not easily reconcilable. This has rendered more complex the simple question of whether technology use improves educational performance or not. Boxes 1.1 and 1.2 provide an overview of the main findings of empirical experiments and observational studies and illustrate this complexity.

In discussing how to interpret the results observed, two extreme positions quickly emerge. On the one hand, there are those who claim that the expectation that technology use would improve educational results should have never been raised. Their argument is that the main benefits of technology in education are not to be found in a productivity analysis focused on academic results, but in a complex combination of educational effects, the nature of which is not subject to objective evaluation. On the other hand, some argue that the issue of whether technology adoption in education is worth the investment can only be duly addressed with an analysis of the cost-efficiency of particular experiments or innovations.

In short, not only policy makers but also teachers and parents may find it difficult to see why technology is important for teaching and learning. They are left with the idea that there is no conclusive evidence or, in the best case scenario, no significant difference between using and not using technology. Some take this as an assertion that at least technology does not cause any harm to students.

Box 1.1. Empirical experiments about the effectiveness of technology in the classroom

Experiments can only attempt to determine how effective technologies are in teaching specific school subjects, owing to the multitude of compartmentalised methodologies to be found in a single school and even in different groups of students studying the same subject with different teachers. Consequently, the experiments designed so far compare the educational attainment of a group of students taught using a technology-rich teaching methodology with the achievements of another group with similar characteristics taught using traditional methods. The preferred subject for this type of analysis is usually maths.

There is a generalised belief that the “no significant difference” phenomenon, documented on many occasions in the case of distance learning, is also verified in school education. Thus, there is insufficient evidence to affirm either the superiority or the inferiority of technology-rich methodologies. This would seem to be the conclusion of two systematic literature reviews conducted recently, one of which concludes that “in general and despite thousands of studies about the impact of technology use on student attainment, it is difficult to measure and remains reasonably open to debate” (Infodev, 2005). The other concludes that “some studies reveal a positive correlation between the availability of computer access or computer use and attainment, others reveal a negative correlation, whilst yet others indicate no correlation whatsoever between the two” (Kozma, 2006).

However, an in-depth analysis of the available knowledge base shows that school attainment only improves if certain pedagogical conditions are met. This is the conclusion reached by Kulik (2003), who used the measurement of the effects found by eight different meta-analyses covering 335 studies before 1990 and 61 controlled experiments whose outcomes were published after 1990. Most of the studies carried out in the 1990s concluded that stimulation programmes have positive effects when used to enhance reading and writing capabilities and that, albeit less frequently, they have a clearly positive effect on maths and natural and social sciences. Indeed, “simply giving students greater access to both computers and Internet resources often results in improved writing skills”. The assessments of primary school pupils using tutorials to improve their writing improved significantly. Even very young primary school pupils who used computers to write stories improved their marks in reading. In short, there is a positive correlation between the frequent use of word processors and improved writing-related capabilities.

One must, however, wonder to what extent these proven improvements stem from the use of technologies or simply from a greater degree of practice in the skills being assessed.

Box 1.2. Correlation studies of the effects of technology in the classroom

Studies of this sort attempt to demonstrate correlation between technology use and educational attainment. Although in some respects they are perhaps not as relevant as empirical experiments, they are useful insofar as they can enlarge the perspective adopted and focus attention on the right questions. Consequently, the aim is to determine whether any sort of association can be found before proceeding with research into how this association works, using empirical experiments whenever possible.

Analysing the studies conducted to date again suggests that there is no consistent relation between technology availability and use, on the one hand, and educational attainment, on the other. Examples of studies of technology use in teaching maths, to name but a few, include some that establish a positive correlation (Cox *et al.*, 2003; National Center for Educational Statistics, 2001; Wenglinsky, 1998). Others demonstrate the opposite (Angrist and Lavy, 2002; Pelgrum and Plomp, 2002). It is even possible to find references (Ungerleider and Burns, 2003) to a certain number of investigations demonstrating that the more computers are used in the classroom, the worse the academic achievement. From an econometric perspective, according to Machin, McNally and Silva (2007), only one study has shown evidence of a positive causal relationship between computers (and/or computer software) and student performance.

The same inconsistency occurs in the analysis of the relation between the use of computers at home and academic attainment. Once again, some studies show a highly positive correlation (Harrison *et al.*, 2003; Ravitz, Mergendoller and Rush, 2003), while others conclude the opposite (Wenglinsky, 1998), including a comparative study of 31 countries based on PISA data (Fuchs and Woessmann, 2004). More recent studies (Kuhlemeier and Hemker, 2007) seem to suggest that a closer look is required, with far more emphasis on the applications and uses of computers than on the mere availability of technology.

The educational productivity paradox

Behind this never-ending discussion there lies a revisited version of the productivity paradox. The classic productivity paradox was formulated to describe the lack of relation between the adoption of a new technology and productivity gains in a business or industry context. As Robert Solow (1987) put it, “you can see the computer age everywhere but in the productivity statistics”. A number of studies carried out in the 1990s found it difficult, if not impossible, to discern, in aggregate economic performance data, the productivity gains expected from massive investments in technology (Brynjolfsson,

1993; Landauer, 1995; Triplett, 1999). The paradox was explained in part by the fact that the investment took time to be fully applied and exploited because there were lags in investment in the skills of workers, the structure of work and organisations, and business strategies. It was thus concluded that much of the payoff of investments in technology would come, not from performing the same functions more efficiently, but by performing new functions that often reflected transformations in processes.

In short, what is expected to follow the adoption of a new technology and justifies the corresponding investment is the expectation of an increase in productivity. But what actually happens is that if a new technology is adopted in a context in which processes are not changed, technology may be found to be useless, if not obtrusive, and may in many cases even lead to a decrease in productivity.

In education, the productivity paradox becomes the educational productivity paradox (Peslak, 2005) or, more recently, the student productivity paradox (Hikmet, Taylor and Davis, 2008). The point is that, in education, technology is a tool that can be used for a variety of purposes. Whether the adoption of technology is linked or not to educational performance will depend on the improvements associated with changes in methodology, which require appropriate technical and pedagogical support. If the methodology remains the same as before the introduction of technology, as is often the case when teachers adopt technology in order to perfect what they were already doing, expectations are low. If, in addition, the intensity of use is low, the amount of preparation time and effort may not be compensated by the educational benefits obtained.

Redefining the question

The right question, therefore, is not which new technology leads to increased productivity, but which new technology-supported methodologies improve student performance over traditional ones and what other factors intervene. Previous efforts have been made to investigate explicit relationships among technology, instructional strategy, psychological processes and contextual factors, for instance by Alavi and Leidner (2001). The almost infinite array of methodological possibilities makes this kind of investigation extremely difficult, but it is not impossible provided that sufficient effort is devoted to the accumulation and dissemination of the resulting knowledge base. This is a major task not only for educational research but also for teacher training institutions, which should contribute to the dissemination of the results obtained. Such a task might appear overwhelming, particularly as the technological frontier is constantly changing. However, it is worth the effort.

Some of the pieces already available of such a knowledge base are well known, but the resulting landscape is still fragmentary. For instance, two

examples of existing research-based knowledge are that the adoption of technology in the classroom increases the motivation and level of engagement of students in the classroom and, as a previous PISA report (see Box 1.3) and this report demonstrate, that home use of technology by 15-year-olds is linked to educational performance. However, these and other similar pieces are not enough to address the knowledge needs of policy makers who could benefit from clear messages based on empirical research.

Box 1.3. Technology use and educational performance in PISA 2003

Analysis of the PISA results (2003) helped clarify the circumstances under which conclusive statements can be made about the correlation between technology use and educational attainment. In more than one respect, PISA shows that this relationship is extremely complex. Consequently, it is hardly surprising that complexity is mistaken for inconsistency.

Indeed, the analysis of PISA reveals that there is a weak but generally positive relation between the use of technology at school and academic attainment. Nonetheless, the conclusions must be approached cautiously. A clear correlation can be established in four respects:

- *Access*: most students who still have limited technology access obtained below-average PISA results.
- *Previous experience*: the lower the experience with technology use, the lower the PISA result. Students with less than a year's experience were capable of only the simplest maths exercises.
- *Frequency of use*: the supposition that more frequent use produces better results is not verified in all countries. An in-depth analysis shows that students with moderate technology use have the best results.
- *Confidence level*: students who are less confident in their ability to carry out daily tasks on a computer or the Internet also had worse results than more confident students.

What is equally or more interesting than these correlations are the conclusions that can be drawn from technology use at home and educational attainment, also on the basis of the PISA database (2003). Probably the most important conclusion is that the correlation is stronger between home use and academic attainment than between school use and academic attainment in most countries, even when allowing for the effects of different socio-economic contexts. In particular, students who do not have access to a computer at home tend to be lower achievers than the others. It also seems to be the case that students using computers at home less often had below-average results.

There is a need to reframe the policy debate about technology in education

As has been shown, initial policy expectations regarding technology in education, as formulated years ago, are no longer current. Technology has contributed to important contextual changes in education, and as a result, those initial expectations have to be reconsidered. Students and societal needs have evolved dramatically and require fine-tuned policy approaches. In particular, and owing to the lack of an appropriate empirical approach and meaningful comparative indicators, the much debated issue of the effectiveness of technology in education remains open. Not surprisingly, the common wisdom among many policy makers is that there is nothing to indicate that, at a system level, the adoption of technology in the classroom comes close to fulfilling the potential that justified so much of the corresponding investment. Does this mean that investments in technology in education are not worthwhile? Is it only the maintenance of existing technology assets, coupled with vendor pressure, that justifies current policies? Certainly not.

Research on technology use and educational performance, in particular as shown in this report, makes it clear that the emergence of new educational needs calls for tailored educational policies. This implies a new framework for the policy debate about technology in education. Policy makers have to be aware of the systemic requirements for sustainable change, *i.e.* the necessary links between curriculum development, teacher training and assessment. What then are these emerging needs and the corresponding policy discussions?

For the most part, the new millennium learners live, like adults, in environments in which technology plays a crucial role. There is no reason why schools should be excluded from this world. Rather, schools could be expected to be leaders in this technology-rich world or at least to be pervaded by technology in ways that help students to better understand and benefit from the opportunities offered by a networked society and economy.

Although most students go to school already equipped with technical skills, this does not make them mature technology users. Even if it is acknowledged that the new generations are appear to be technologically “savvy”, as reflected in the term new millennium learners, this does not automatically make them better or more effective learners. Moreover, in the absence of educational attention, students cannot develop the competencies required to enhance their education by implementing these technical skills on their own.

Not all students are equally new millennium learners. As the digital access gap narrows, a new form of divide seems to be emerging: the digital use divide. This far more subtle divide has to do with the different uses of technology and the associated benefits, which are determined by socio-economic status and

education. Education should actively engage in the struggle against this new form of digital divide.

There is an even greater need to sustain technology-supported educational innovation in ways that contribute to making schools better suited to the needs and work of a networked society. To do this effectively is not just a matter of financing, but even more of monitoring and assessing what works in education and disseminating this information in ways that are meaningful to teachers and suitable for scaling up. The pending issue of how technology use relates to educational performance can be explored using PISA data and will be done more in the future, but empirical research and experiments will also have to be carried out as to build a useful knowledge base.

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Chapter 2

Students' access to information and communication technologies

The analysis of students' access to ICT takes a multidimensional approach to access to ICT resources to look not only at physical access but also at students' opportunities to use ICT resources for educational purposes at home and at school, across and within the countries. While OECD countries have made significant progress in physical access to computers at home and at school, more efforts should be made to enrich the educational opportunities offered by ICT resources in particular regarding access to the Internet and to quality digital learning resources.

The evolving meaning of students' access to ICT

The notion of *access* to ICTs has evolved in the past years. Initially it was understood as making physical or technical ICT resources (e.g. computers, Internet connection, computer software) available to all citizens or to groups of people considered as a national policy priority (e.g. students). In this sense, it was defined as a binary concept: the “have” and “have-nots” of different groups regarding certain digital resources. Very useful quantitative data have emerged from this approach and provide a general comparative picture of the situation and evolution of countries and groups within countries in terms of the formal provision of information technologies in homes and other places. In the educational field this is commonly expressed in terms of data, such as percentages of schools or students with access to certain ICT resources, number of students per computer, and total numbers of ICT resources in schools available for teachers and students. This is also the source of the definition of the digital divide as the gap between those who have physical access to ICT and those who do not.

Over the years, and as understanding of the requirements and implications of the knowledge society increases, this binary concept has become more complex. New dimensions have been added which relate to the context or conditions of ICT access (Selwyn, 2004). These conditions are important because they determine or mediate the “quality” of access. For example, for a student, it is very different to work on a research project at home with a personal computer with broadband Internet connection and no time restrictions or to work on the same project in a school computer lab with a dial-up Internet connection and restricted schedules of use. As this example shows, place of access for doing schoolwork, time constraints, quality of the technology and privacy conditions can be very dissimilar. Consequently, the notion of access is now multidimensional and includes not only quantitative (e.g. number of computers in schools) but also qualitative aspects (e.g. access to computers for educational use). This leads to a more complex concept of the digital divide, which concerns not only the gap between groups in terms of technical or physical access but also in terms of the conditions or opportunities of access. Therefore, the OECD defines the digital divide as “the gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard to both their opportunities to access information and communication technology (ICT) and to their use of the Internet for a wide variety of activities.” (OECD, 2001, p. 8)

The following analysis therefore takes a multidimensional approach to access to ICT resources, looking not only at physical access but also students' opportunities to use ICT resources with educational purposes at home and at school, across and within the countries participating in the survey.

Access to ICT resources

The physical access of 15-year-old students to ICT resources is analysed in terms of three main indicators: first, if students have ever used computers; second, if students have used computers, for how long; and third, by numbers of computers per student at school. Access to an Internet connection is also very important, and this is analysed as part of students' opportunities to use ICT for educational purposes. Although the 2006 PISA ICT questionnaire did not ask students the purpose of their use of the Internet, access to the Internet will be considered here as an ICT resource relevant for educational use because an Internet connection opens the door to an enormous amount of digital resources, many of them relevant for learning.

It is important to bear in mind that the values presented¹ are not real values, but the most plausible values. Therefore, comparisons between countries must be interpreted with caution.

Have students ever used computers?

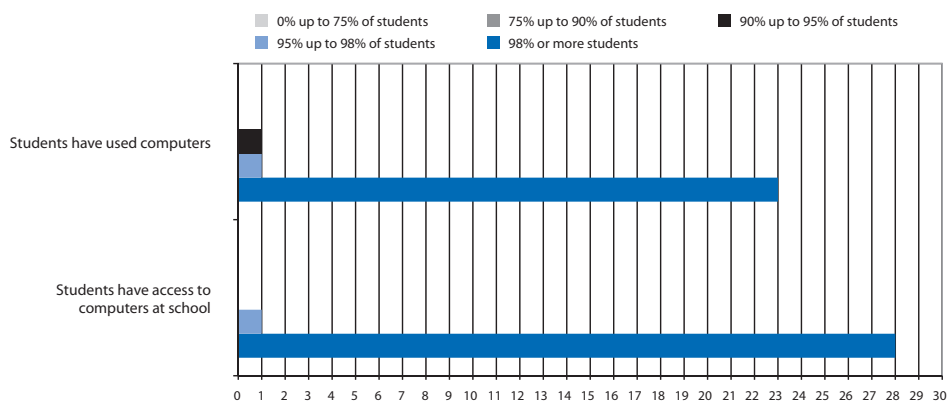
As noted above, the presence of a computer at home, in the public library or in the school computer lab does not say enough about students' actual access to ICT resources. Thus, a first aspect of physical access is whether students have ever used computers. In most countries, all but a very small minority have used them by the time they are 15 years old (Figure 2.1). Only in 15 of the 40 countries surveyed, do more than 1% say that they have never used a computer: only in one OECD country, Turkey; with 6.6%, and two partner countries, Qatar, 5.1% and the Russian Federation, 6%, is this figure above 5% (Annex A, Table A.1). Compared to PISA 2003, most of the countries that participated in both surveys roughly maintained the same percentage – below 1 percentage point of difference between the two years.

To what extent is gender related to students ever using a computer?

In most countries, there were no significant gender differences in the percentages of students who had never used a computer. However, as in PISA 2003, the percentage of female students who had never used a computer in Turkey was more than double that of male students, at 10% and 4%, respectively. It is noteworthy that with this exception, in all cases where the difference between males and females is greater than 1 percentage point, the difference favours women (fewer females than males have never used a computer) (Annex A, Table A.1).

Figure 2.1. **How universal is computer access?**

Number of OECD countries by percentage of students who have used and have access to computers



Note: 24 countries answered the first question and 29 the second.

Source: OECD PISA 2006 database.

To what extent do students who have never used a computer come from disadvantaged backgrounds?

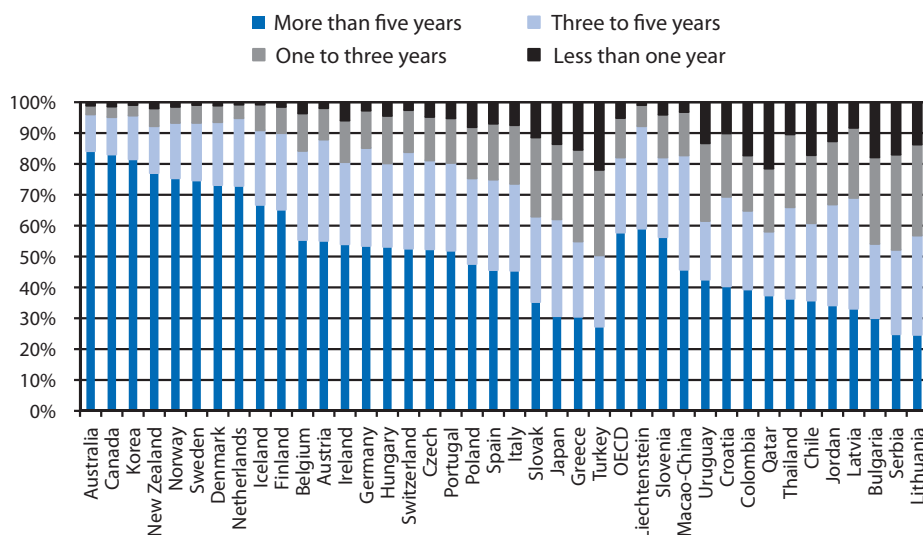
In most countries, among students who have never used a computer, there are no significant differences in terms of PISA's index of economic, social and cultural status (ESCS). That is, students in the bottom quarter of PISA's ESCS index are not much more likely to have never used a computer than those in the top quarter. However, in one OECD country and six partner countries there is a difference of more than 5 percentage points between the bottom and the top quarter. In Turkey, there is a difference of 12 percentage points, and in partner countries the differences are as follows: Bulgaria (10 percentage points), Colombia (5 percentage points), Jordan (7 percentage points), Qatar (8 percentage points), the Russian Federation (9 percentage points) and Serbia (11 percentage points).

Among students who have used a computer, for how long have they used them?

A second aspect relevant to physical access to computers is how long students have used a computer. As discussed in the PISA 2003 ICT report, this is relevant partly because students who first use computers in their mid-teens are less likely to be comfortable using them than those whose experience dates from their primary or early secondary school years. However,

there is evidence showing that more experience (*i.e.* more practice) using technologies is positively related to the acquisition of digital skills and to confidence using these tools. Figure 2.2 shows that in 18 of the OECD countries and in two partner countries a majority of 15-year-old students have at least five years' experience with computers, that is, since primary education. In the other surveyed countries, 7 OECD countries and 13 partner countries, a minority of students have used computers since primary education. Nevertheless in all surveyed countries except Turkey and the Russian Federation, the majority of students have at least three years of experience, and thus started using computers at least when they entered secondary education. The number of OECD countries with a majority of 15-year-old students with at least five years' experience with computers has increased since PISA 2003, when this was the case for only seven OECD countries. These comparisons should be interpreted with caution, as the participating countries were not all the same in the two years. It should also be noted that there are big disparities within some countries in terms of students' years of experience, particularly in partner countries.

Figure 2.2. Length of time students have been using a computer



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OECD and partner countries are grouped separately and ranked in descending order of students who have been using computers for more than five years.

Source: OECD PISA 2006.

ICT resources available at school

A third relevant aspect of students' physical access to ICT resources is whether they have access to computers at school and how many are available for them. The number of students per computer is very important, as students' experience with ICT partly depends on the number available to them. PISA 2006 shows that the great majority of students have some access to computers at school. According to principals' responses to the PISA school questionnaire in all OECD countries except Mexico, 100% of students are in schools with at least one computer. In Mexico, this is the case for 98% of students.

As for number of students per computer, Australia, Liechtenstein, Norway and the United Kingdom have more or less three students per computer. Austria, Canada, China, Denmark, Hong Kong (China), Hungary, Iceland, Japan, Korea, Luxembourg, New Zealand, Switzerland and the United States have more or less five students per computer. Belgium, Chinese Taipei, Colombia, the Czech Republic, Finland, Germany, Greece, Ireland, Israel, Italy, Qatar, Macao (China), the Netherlands, Slovenia, Spain and Sweden, have more or less ten students per computer. In the rest of the countries there are more than ten students per computer (Figure 2.3a). In OECD countries, the average is 0.19, very close to the average of 0.2 in PISA 2003, and close to 0.1 higher than in PISA 2000 (Figure 2.3b).

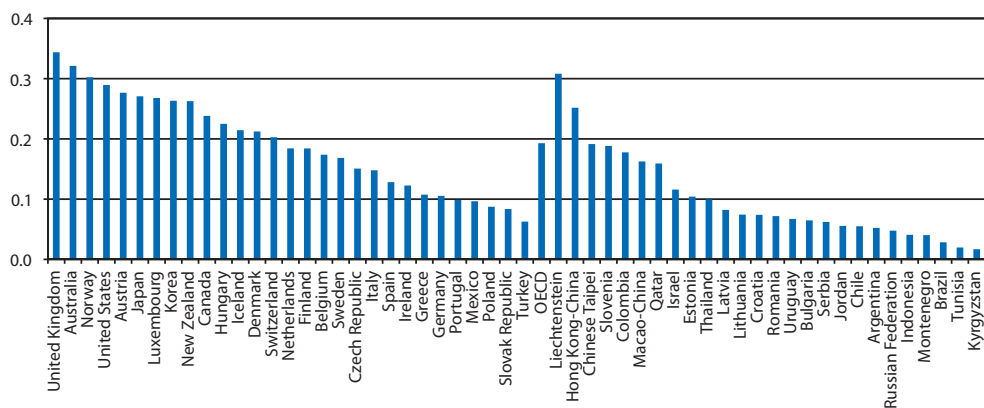
As noted above, formal availability of computers at school does not say enough about the actual opportunity to use computers. Therefore, it is also relevant to analyse the percentage of students who declared that they never used a computer at school. As Figure 2.4 shows, the OECD average for students who declared they never used a computer at school is 12.06%. The range is from 1% in Denmark to 41.8% in Korea.

Is gender related to never using a computer at school?

In most OECD countries there are no significant gender differences among students who declared they never used a computer at school. On average among OECD countries, there is a difference of less than 1 percentage point between females and males who declared never using a computer at school (13.3% and 12.6%, respectively). In only three countries are gender differences significant: Austria, where almost twice as many males as females declared they never used a computer at school (8% and 4.3%, respectively); Italy where the difference is 7.4% (26% and 18.6%, respectively); and Greece where the difference is 12.7% (32% and 19.3%, respectively).

Figure 2.3. ICT resources at school

Figure 2.3a. Number of computers per student

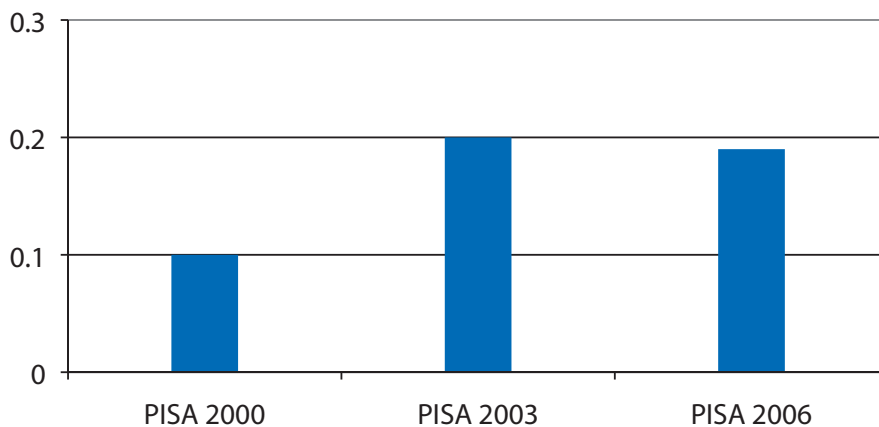


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OECD and partner countries are grouped separately and ranked in descending order of number of computers per student.

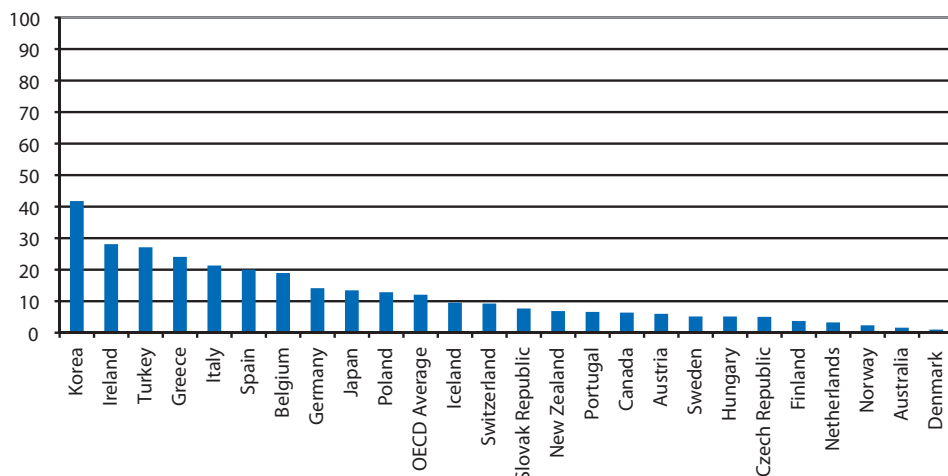
Source: OECD PISA 2006 Database.

Figure 2.3b. OECD average of computers per student, years of PISA survey



StatLink <http://dx.doi.org/10.1787/811743484603>

Source: OECD PISA 2006, PISA 2003 and PISA 2000 Databases.

Figure 2.4. **Percentage of students who declared never using a computer at school**

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Source: OECD PISA 2006 Database.

Access to ICT resources for educational use

As mentioned, access to ICT resources that are relevant for education relies not only on the physical presence of ICT resources at home or at school but also on the possibility for students to use them for schoolwork and other educational purposes. This section presents evidence from the student and school questionnaires from the 57 countries participating in PISA (not just the 40 that took part in the extra ICT survey) on access to ICT resources for educational use at home and at school.

To what extent can students' home-based computers and other resources be used for educational purposes?

Comparing the evolution and use of traditional and new ICT educational resources is a way to study whether new technologies are complementing traditional educational resources or whether some of them may be starting to replace traditional ones. Figure 2.5 shows students' responses to questions about whether they had a computer they could use for schoolwork, educational software, a link to the Internet and books to help with their schoolwork at home, ordered by the percentage of students with a home computer to use for schoolwork. Even though the item "a link to Internet" does not specify the purpose of use, access to the Internet can represent a qualitative difference in terms of educational resources, owing to the opportunities it affords for

access to digital educational resources. Although word processing, educational software and other programmes that are relevant for educational purposes can be used on computers without access to the Internet, students without Internet access are excluded from many resources available at educational portals as well as the information available on the World Wide Web for research and other educational activities. Even more, such students do not have the opportunity to develop the skills necessary for effective Internet use, which are increasingly important for full participation in the knowledge society.

Computers were available at home for schoolwork for at least 95% of students in 16 countries and for 98% in Denmark and Iceland. In most countries surveyed at least 50% of students had computers for schoolwork at home. The OECD average was 86.9% of students with access to computers for homework at home, and at least 75% in most countries. The exceptions were Greece (74%), Japan (62.5%), Mexico (42%) and Turkey (38.2%).

Internet access at home is somewhat more limited. In half of the countries with at least 95% of students with a computer available for schoolwork at home, at least 95% also had a link to the Internet. All except Liechtenstein were OECD member countries. The OECD average was 76.4% of students with Internet access at home, and at least 75% had this resource in 20 countries. In France, Italy and Spain the range was between 74.9% and 65% of students; in Greece, Iceland, Poland and Portugal, it was between 64.9% and 50%; and in Mexico, the Slovak Republic and Turkey, a minority of students had Internet access at home.

Based on PISA 2003 and PISA 2006 data, the average percentage of students with access to a computer for schoolwork at home in OECD countries increased over the period by 6.6 percentage points, while access to an Internet connection at home increased by 11.8 percentage points. The largest increases in access to a computer for schoolwork use at home were in Finland, France, Ireland, Mexico, Spain and Turkey (7.1 to 10 percentage point increase); the Czech Republic, Italy, Portugal and Turkey (10.1 to 15 percentage point increase); Hungary, Japan, Poland and the Slovak Republic (15.1 to 20 percentage point increase); and Greece (21.2 percentage point increase). The largest increases in access to an Internet connection at home were in Austria, Belgium, Denmark, Germany, Ireland, Japan and Switzerland (12.1 to 15 percentage point increase); the Czech Republic, Finland, France, Greece, Poland, and Spain (15.1 to 20 percentage point increase); the Slovak Republic (22.8 percentage point increase); and Hungary (24.7 percentage point increase). Comparisons of partner countries are more difficult because only a minority participated in both years. Nevertheless, two cases stand out: in Latvia access to a computer for schoolwork at home increased by 28.7 percentage points and Internet access at home increased by 35.9 percentage points; in Serbia the corresponding increases were 33.9 percentage points and 25.7 percentage points (Annex A, Table A.2).

Comparisons between educational resources at home

In most OECD countries there is a difference of less than 5 percentage points between the percentage of students with access to computers for schoolwork and the percentage of students with a link to the Internet. In Ireland, Luxembourg and Germany and in partner countries Bulgaria and Israel, the difference is between 5 and 10 percentage points; in Austria, Italy, Mexico and Turkey, it is between 10 and 20 percentage points. Japan is an interesting exception in that 12% more students have access to the Internet at home than have access to computers for schoolwork, which suggests that a significant percentage of students with computers at home with a link to the Internet do not use them for schoolwork.

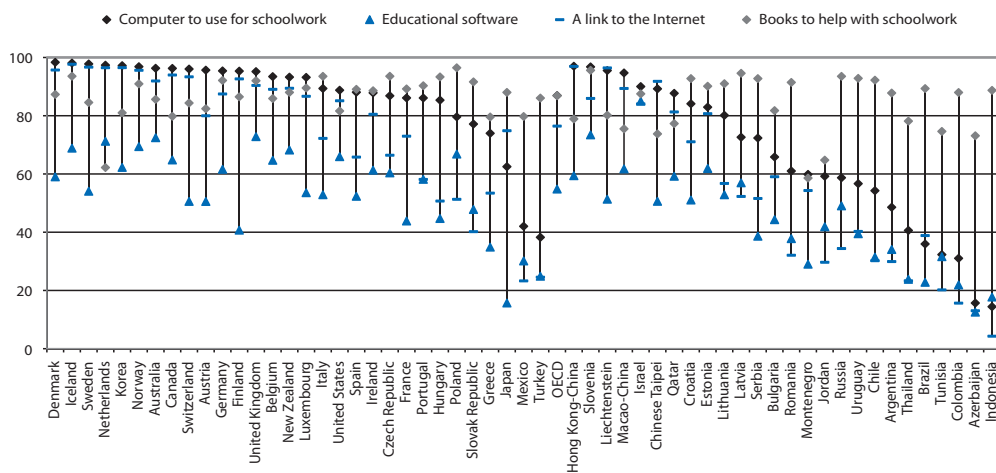
Figure 2.5a shows how many students have books to help with their schoolwork at home. In 54 out of 57 countries, at least three-quarters of students report having this resource. The percentage of students who report having books to help with their schoolwork at home range between 62% and 97% across OECD countries in PISA 2006 (compared to 42% et 92% for PISA 2003). The range is smaller than for the percentage of students who report having computers at home to use for schoolwork, between 38% and 98% in PISA 2006 (compared to 23% and 97% in PISA 2003).

Comparing the number of students with computers and a link to the Internet with those who have books to help with their schoolwork at home, the balance in the availability of these resources differs across countries. In countries where over 90% have computers for this purpose, fewer have books. In countries where fewer than 90% of students have computers, more have books than computers, with the exception of the United States and of partner economies Chinese Taipei, Montenegro and Qatar. As Figure 2.5a shows, the distance between the percentage of students having books and the percentage of students having computers for schoolwork generally increases as access to computers for schoolwork decreases. A similar tendency is observed when comparing books for schoolwork and a link to the Internet at home.

Finally, Figure 2.5a also shows that, in general, books for schoolwork are relatively more present than educational software in students' homes. In all countries, a higher percentage of students have books for schoolwork than educational software. As in the case of computers for schoolwork, the distance between the percentage of students who have books for schoolwork and the percentage of students with educational software at home increases as access to educational software decreases, except in Jordan and Montenegro. In addition, of the four ICT resources, the smallest percentage of students had access to educational software at home in most countries. Nevertheless, over 70% have this resource in Australia, Canada, the Netherlands and the United Kingdom, and over 85% in Israel. Finally, in countries where the minority of

Figure 2.5. ICT and educational resources at home

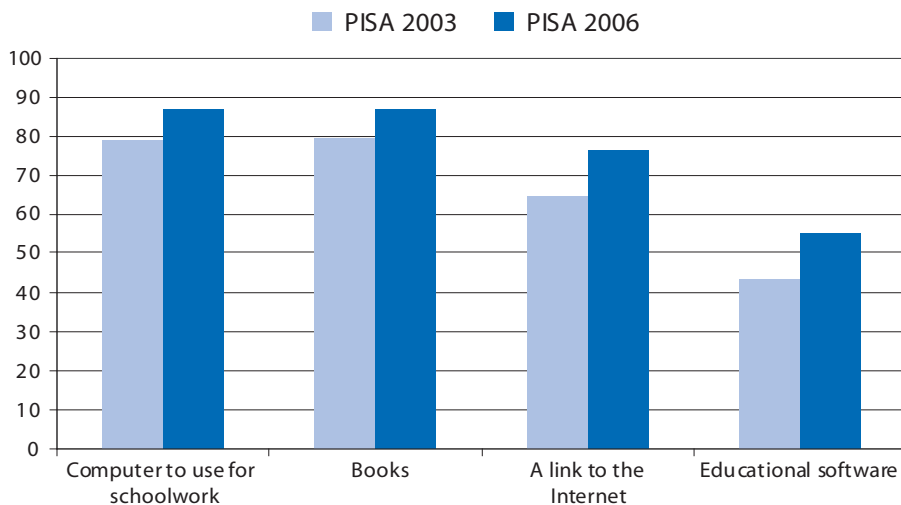
Figure 2.5a. Percentage of students with access to ICT and educational resources at home



OECD and partner countries are grouped separately and are ranked in descending order of percentage of students with a computer at home to use for school-work

Source: OECD PISA 2006 Database.

Figure 2.5b. Percentage of students with access to educational resources at home



Source: OECD PISA 2003 and PISA 2006 Databases.

students have Internet access at home, educational software was relatively more important (*i.e.* a relatively higher percentage of students had educational software than an Internet connection at home); the only exceptions are Brazil and Azerbaijan.

A comparison with data from PISA 2003 for OECD countries shows that on average the percentage of students with access to computers for schoolwork increased by 6 percentage points, with a link to the Internet increased by 11.8 percentage points, with educational software by 10.3 percentage points and with books for schoolwork by 7.6 percentage points (Figure 2.5b).

To what extent does access to ICT and to other educational resources at home depend on the students' socio-economic background?

Among OECD countries differences between students in the top and bottom quarters of the PISA index of ESCS, in terms of how likely they are to have computers for use with schoolwork decreased from 36% in PISA 2003 to 25% in PISA 2006. In PISA 2003 an average of 94% of students with the most favourable socio-economic background reported having this resource, but only 58% of students with the least favourable background. In PISA 2006 an average of 97% of students with the most favourable socio-economic background reported having this resource and 72% in the bottom socio-economic quarter. The OECD countries with the biggest differences between the top and bottom quarters in PISA 2006 were Mexico (80 percentage points) and Turkey (69 percentage points). The majority of partner countries (21 out of 27) have more than 25 percentage points of difference between the top and the bottom quarter. The exceptions by ranking order are Israel (22%), Chinese Taipei (14%), Macao, China (11%), Slovenia (8%), Indonesia (6%) and Liechtenstein (no difference) (Annex A, Table A.3).

For educational software, the differences are relatively marked in many OECD countries: on average, a student in the top socio-economic quarter is twice as likely as a student in the bottom quarter to have educational software. The distance has decreased since PISA 2003 when a student from the top socio-economic quarter was three times as likely to have this resource as a student from the bottom quarter. For a link to the Internet, the difference is also quite large in many OECD countries: on average there is a difference of 35.5 percentage points between the top and the bottom socio-economic quarter.

For books to help with schoolwork, the difference by socio-economic background is relatively small. On average in OECD countries the relation between socio-economic background and the likelihood of having both books and computers at home to help with schoolwork is quite similar: 75% of students in the bottom quarter have books available at home, compared to 96% in the top quarter; the figures are 72% and 97%, respectively, for computers.

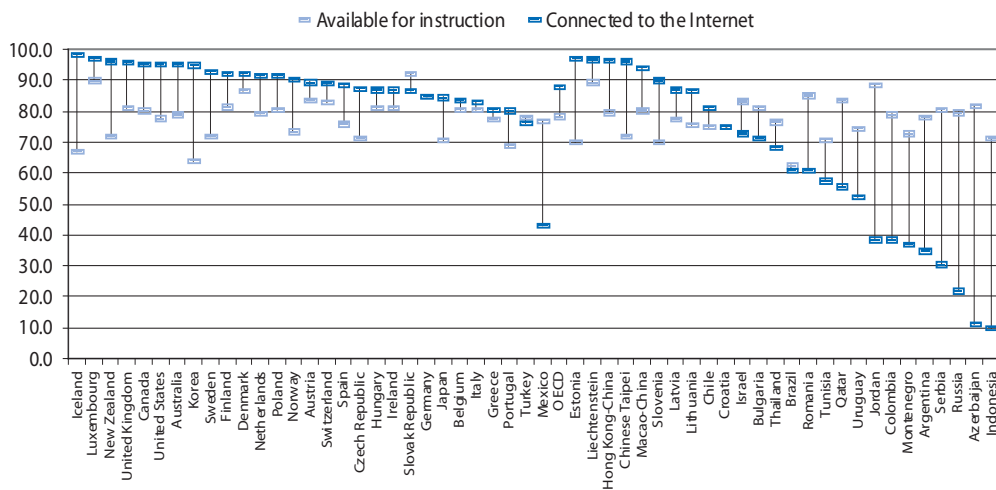
This is generally not the case however for partner countries, where the difference between students in the top and bottom socio-economic quarter with books available at home is half the difference between the top and bottom socio-economic quarter of students with computers available at home for schoolwork (a difference of 23% and 47 percentage points, respectively).

Consequently, students' socio-economic background still plays a strong role in terms of access to educational resources at home, especially for those related to ICT, although the differences are decreasing over time in OECD countries thanks to the sharp increase in the access of students in the bottom quarter.

To what extent can students' school-based computers be used for educational purposes?

In all countries surveyed the majority of computers in schools are available for instruction. The differences among all countries surveyed are within a relatively small range of 64% to 92%. Instead, as Figure 2.6 indicates, the differences between countries in terms of the percentage of computers connected to Internet ranges from 1.8% in Kyrgyzstan to 98% in Iceland. On average among OECD countries, 88% of computers at schools are connected

Figure 2.6. **Percentage of computers in schools connected to the Internet and available for instruction**



StatLink  <http://dx.doi.org/10.1787/811815080484>

OECD and partner countries are grouped separately and ranked in descending order of percentage of computers connected to the Internet

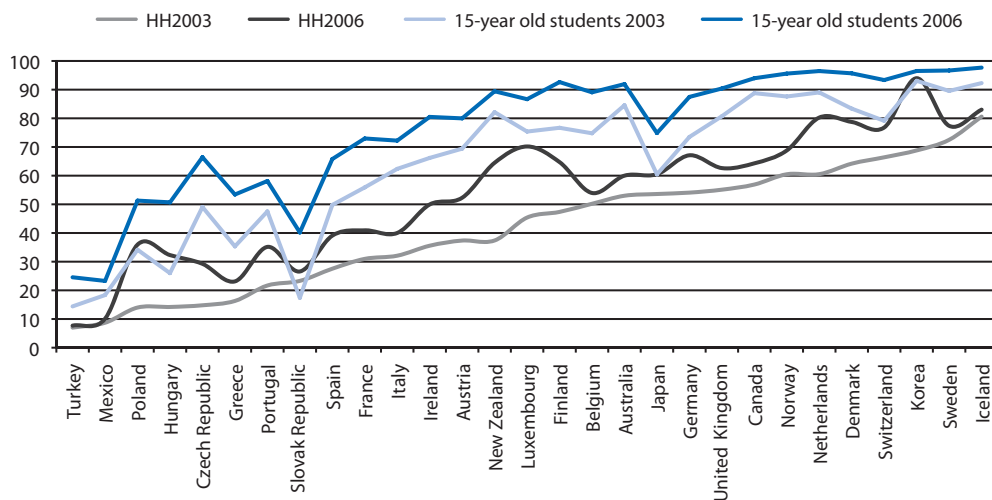
Source: OECD PISA 2006 Database.

to the Internet, a much higher level than in most partner countries. It is also noteworthy that, with the exception of the Slovak Republic, when at least 80% of the computers in a school are connected to the Internet, the percentage available for instruction is somewhat smaller. When less than 80% of the computers in a school are connected to the Internet, the percentage available for instruction is much higher. This suggests that when a certain level of access to computers connected to the Internet is achieved, uses at schools might start to diversify.

To what extent does access to ICT resources at school depend on socio-economic background?

On average, in OECD countries there is almost no correlation (-0.01) between the socio-economic background of students and never using a computer at school or with what schools' principals report in terms of the proportion of computers at their school available for instruction (-0.04) or connected to the Internet (0.05). These results are interesting, as they suggest that schools in OECD countries on average do not seem to discriminate positively or negatively for students from lower ESCS (Annex A, Tables A.4a, A.4b and A.6).

Figure 2.7. Percentage of 15-year-old students with an Internet connection at home and percentage of households (HH) with Internet connection (2003 and 2006)



StatLink  <http://dx.doi.org/10.1787/811831847127>

Source: OECD Stat (data extracted 22 October 2008) and PISA 2006 Database.

To what extent does access to ICT resources depend on the school's location (rural locations and towns versus cities)?

In most countries there is no difference or only a small one in the number of computers per student between schools in rural locations or towns and schools in cities. In fact, for OECD countries the average is 0.2 computer per student in schools in rural locations or towns as well as schools in cities. The biggest differences (above 0.1) are in Austria (0.13) and Korea (0.14), where schools in cities have more computers per student than rural locations and towns, and Luxembourg (0.57), where it is the reverse (Annex A, Table A.5).

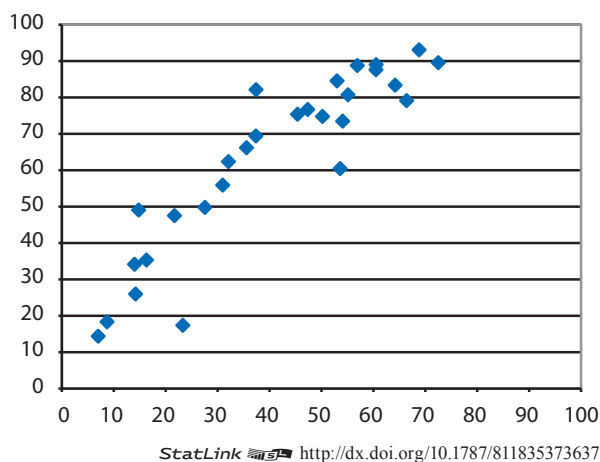
Figure 2.7 shows that in OECD countries access to the Internet at home is generally higher for 15-year-old students than for households on average in their countries, confirming once again that households with children have higher percentages of ICT adoption. Nevertheless, as the figure and Table 2.1 indicate, OECD country households seem to be catching up, owing to the more rapid rate of increase of Internet connections: between 2003 and 2006 the increase for households was 11.7 percentage points (a 28% increase), while for 15-year-old students it was 12.1 percentage points (an 18% increase). Additionally, although this does not account for causality, Figures 2.8a and 2.8b show a high correlation (around 0.9) between countries' households and 15-year-old students' access to the Internet in each of the two years.

How does the instructional environment related to ICT resources and ICT-related activities vary between countries?

School principals' perceptions offer another way to look at the conditions of access to ICT resources for educational purposes. School principals reported on whether the capacity of their schools to provide instruction was hindered by a shortage or inadequacy of computers or computer software. As stated in the PISA 2003 report, school principals' subjective judgements should be interpreted with caution, because cultural factors and expectations may influence the degree to which principals consider shortages a problem.

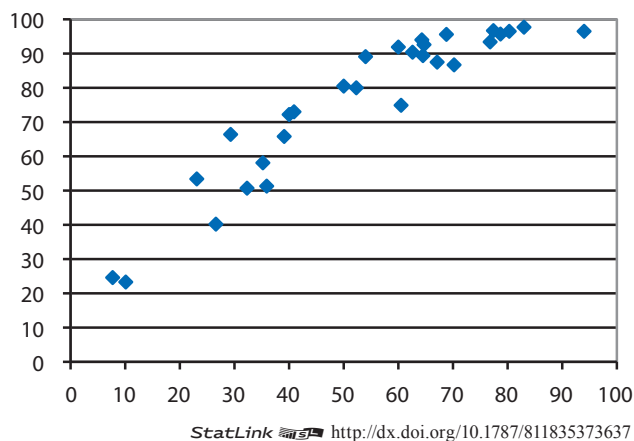
The percentage of students in schools whose school heads reported that instruction was hindered a lot or to some extent by a shortage of computers for instruction varied from a small minority in some countries to a great majority in others. In partner country Liechtenstein, no students are in such schools, and in OECD countries Hungary, Japan and Switzerland and partner economies Chinese Taipei and Macao, China 20% or fewer students are in such schools. However, at least 76% of students are in schools whose principals have these concerns in partner countries Azerbaijan, Brazil, Kyrgyzstan, Montenegro, the Russian Federation and Tunisia. In most countries the percentage of students in schools whose principals reported that instruction was hindered a lot or to some extent by a shortage of computers for instruction ranges from 21% to 70% (Figure 2.9).

Figure 2.8a. Correlation between OECD country households and 15-year-old students' access to the Internet at home (2003)



Source: OECD Stat (data extracted 22 October 2008) and PISA 2006 Database.

Figure 2.8b. Correlation between OECD countries' households and 15-year-old students' access to the Internet at home (2006)



Source: OECD Stat (data extracted 22 October 2008) and PISA 2006 Database.

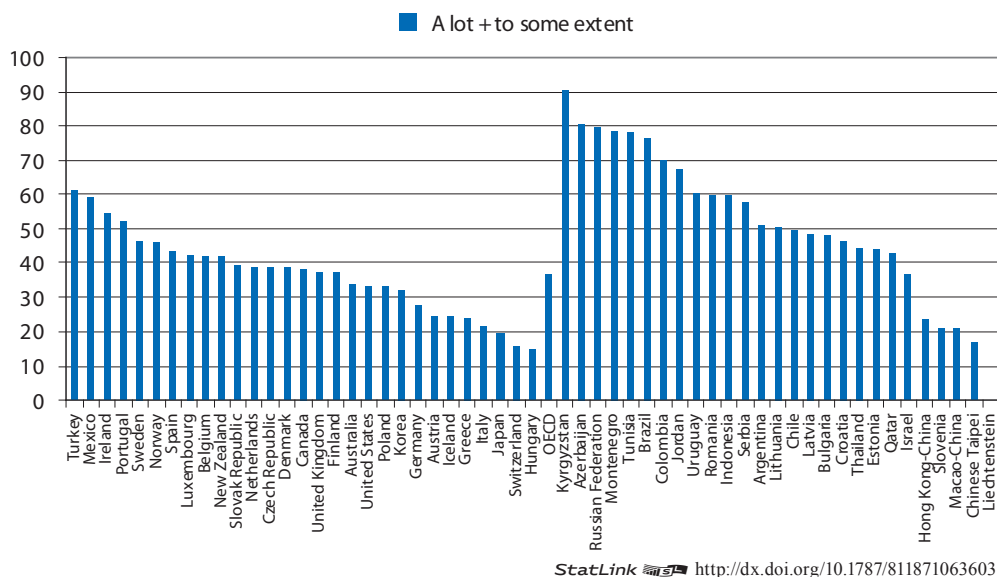
Table 2.1. Percentage of 15-year-olds with an Internet connection at home and the percentage of households (HH) with Internet access (2003 and 2006)

	HH 2003	HH 2006	15-year-old students 2003	15-year-old students 2006	HH increase 2003-06	Students increase 2003-06
Turkey	7.0	7.7	14.4	24.6	0.7	10.1
Mexico	8.7	10.1	18.4	23.3	1.4	4.9
Poland	14.0	35.9	34.2	51.3	21.9	17.1
Hungary	14.2	32.3	26.0	50.7	18.1	24.7
Czech Republic	14.8	29.3	49.1	66.4	14.5	17.4
Greece	16.3	23.1	35.3	53.4	6.8	18.1
Portugal	21.7	35.2	47.5	58.1	13.5	10.6
Slovak Republic	23.3	26.6	17.4	40.2	3.3	22.8
Spain	27.5	39.1	49.8	65.8	11.5	16.0
France	31.0	40.9	55.9	73.0	10.0	17.1
Italy	32.1	40.0	62.4	72.2	7.9	9.9
Ireland	35.6	50.0	66.2	80.5	14.4	14.3
Austria	37.4	52.3	69.4	80.0	14.9	10.6
New Zealand	37.4	64.5	82.1	89.4	27.1	7.3
Luxembourg	45.4	70.2	75.4	86.7	24.8	11.3
Finland	47.4	64.7	76.7	92.6	17.4	15.9
Belgium	50.2	54.0	74.8	89.1	3.8	14.3
Australia	53.0	60.0	84.6	91.9	7.0	7.4
Japan	53.6	60.5	60.5	74.9	6.9	14.4
Germany	54.1	67.1	73.5	87.5	13.0	14.0
United Kingdom	55.1	62.6	80.7	90.4	7.5	9.7
Canada	56.9	64.3	88.8	94.0	7.4	5.2
Norway	60.5	68.8	87.6	95.6	8.3	8.0
Netherlands	60.5	80.3	89.0	96.5	19.7	7.5
Denmark	64.2	78.7	83.4	95.7	14.5	12.3
Switzerland	66.4	76.8	79.1	93.4	10.4	14.2
Korea	68.8	94.0	93.1	96.5	25.2	3.4
Sweden	72.5	77.4	89.6	96.7	4.9	7.1
Iceland	80.6	83.0	92.3	97.7	2.4	5.4
United States ¹	--	--	81.8	85.1		
OECD			64.0	76.1	11.7	12.1

Note: 1. As no data was available for households in the United States, this country was excluded when calculating OECD averages.

In cases where data were not available for 2003 or 2006, data from the nearest available year were used.

Figure 2.9. **Percentage of students in schools whose principals report that instruction is hindered by a shortage of computers for instruction**



Source: OECD PISA 2006 Database.

Countries that participated in PISA 2000, 2003 and 2006 show different patterns of response to this question from one survey year to the next (Annex A, Table A.7). These responses should be interpreted with caution, because a decrease or increase in the percentage of school heads reporting that instruction was hindered by shortage of computers does not necessarily mean that more or fewer computers were available for learning. It could also mean that these school principals became more aware of the relevance of computers for learning or were unhappy with their experience with the use of computers for learning.

What can SITES 2006 say about access to ICT at schools?

The IEA SITES 2006 study² offers a complementary analysis in terms of access to ICT at schools from a comparative perspective. Compared to SITES 1998, there has been an overall increase in computer density (decreasing ratios of students per computer, increased access to computers at home, increased deployment and use of laptops) and in the available software, with respect to both quantity (the number of computers available) and quality (upgrading of old equipment and software). In particular, the use of ancillary learning resources such as multimedia seems to be on the increase.

Concerning the availability of computers and software, the systems vary significantly. Not surprisingly, this variation tends to be distributed along a global axis of development level, with developed countries in general exhibiting a more favourable situation (lower SCR, more widespread deployment of software) than developing countries. (This is often referred to as a “north-south” divide, but this can be misleading: “southern” countries such as Australia are considerably more developed than many of their “northern” neighbours). In other words, richer countries tend to have better-equipped schools than poorer countries. This equipment gap is shrinking, though, as a result of accumulated investments over the last decade, but also as a result of the recognition on the policy level of the need for a digitally literate workforce to maintain economic growth. An example is the Malaysian Smart School Initiative: “To produce a technologically literate workforce that can think critically as a result of encouraging thought and creativity across the curriculum and applying technology effectively in teaching and learning.”

In general, the main challenges for deploying ICT in economically poor educational systems are similar to those of their richer counterparts. But problems such as lack of electricity, lack of networks of hardware and software providers on a local level, lack of teachers, lack of textbooks, high dropout rates among students, and marked differences between the levels of public and private schools pose additional problems for the economically poorer systems.

Other barriers to greater access, as identified by Ottestad and Quale (2009) include:

- *Language*: English is the dominant language of information on the Internet, and proficiency in English is generally presumed in the user interface of most application software. Several education systems report this as a major barrier for many students.
- *Teacher education*: there is a widespread need to extend and improve the professional training of teachers. A main obstacle here, in particular for developing countries, is funding. In addition, some countries (e.g. Brazil) point to a lack of understanding in the governmental bureaucracy of the need to devote sufficient resources to upgrading hardware and to promoting good pedagogical practices in using this equipment. There is also an issue of *organisation*: for instance, some countries (e.g. Australia) indicate a lack of connection between pre-service and in-service teacher education in areas associated with ICT.
- *Pedagogy and time constraints* are identified by many as major barriers to the use of ICT. It is not clear to many teachers how it can contribute profitably to their teaching. It is also difficult to find time to train students in the use of ICT and to give them sufficient opportunity to use it given the crowded schedules of most curricula. In

this connection, there is a perceived need to improve teachers' competence in applying ICT to student-centred pedagogical practices, particularly in mathematics and the sciences.

- *Hardware*: many countries – in particular, among the less economically developed – report a lack of sufficient hardware (computers, Internet connections), which impedes the adoption of ICT as part of pedagogical practice. In some cases, this is also an issue of *geography*: the challenge of providing a satisfactory level of technology and technological competence to schools in remote, and often sparsely populated, rural areas.
- *Gender and age*: recent studies – particularly of the Nordic countries (Denmark, Finland, Norway and Sweden) – point to a continuing issue of gender and age. Boys and young men (aged 10-30) are the most active, and the most proficient, users of digital hardware (computers and various peripherals). Moreover, boys tend to learn to use computers at home, with friends and/or when pursuing hobbies; girls are more dependent on school as a place for learning ICT skills. A number of policies are being considered to address this problem of gender inequity regarding the use of computers in the classroom teaching situation.

As for the student-computer ratio, the Internet access ratio is skewed in favour of the industrialised educational systems. However, when the dispersion is broken down on the individual system level, there is a strong push towards connecting schools as a desirable state or goal.

Conclusions and policy recommendations

From the perspective of education, access to ICT resources is not only about the physical provision of ICT resources, but also about the actual opportunities or conditions students have to use these tools for educational purposes. In this context, the main concern today is whether once all groups of students have access to technologies they also have the means of taking full educational advantage of them. The results from PISA data show that while OECD countries have made significant progress in physical access to computers at home and at school, more efforts should be made to enrich the educational opportunities offered by ICT resources. First, in most of the countries surveyed, the majority of students have access to computers for schoolwork at home and at school, but access to a link to the Internet is more limited and varies greatly across and within countries. This is a matter of concern, as in countries in which a minority of students have access to the Internet, the learning opportunities ICT resources can provide at home and at school are much more limited. In addition, although the difference between the highest and lowest socio-economic quarters by ESCS has decreased since PISA 2003, the socio-economic background of students still plays an

important role in the opportunity to use a computer for schoolwork and to have a link to the Internet at home. Governments should therefore increase their efforts to connect school computers to good quality Internet services, and schools should give priority of access (especially after school) to students without a computer to use for schoolwork or a link to the Internet at home.

Second, the comparison between ICT and other educational resources available at home showed that while books were the most “democratic” educational resource, educational software was the resource least present in OECD 15-year-old students’ homes. Although PISA 2006 does not provide detailed information about access to educational software at school, the results show that educational software is the least used of these resources among OECD countries. This raises the question of the role that educational software and digital learning resources (DLR) play in schools and homes. Several experiments have shown that DLR can be relevant when information and learning materials are offered in innovative and motivating ways to students. However, they have not found their way into the majority of today’s classrooms and homes. This is why it is important to learn more about the actual levels of use of such resources in the classroom, how they contribute to the quality of learning and about factors that can promote or prevent their dissemination. This matter is at the heart of issues concerning how ICT can support an effective teaching and learning process and how schools can become places where ICT reach their full educational potential. This is why the OECD’s Centre for Educational Research and Innovation has recently started an activity to address these and other issues at an international comparative level. As a complement, governments should support deep research on these issues at a local level.

Finally, although the data provided offer a valuable comparative picture of physical access to ICT as well as general opportunities of access for schoolwork in the participating countries, it has limitations that call for new and more specific data:

- Conditions of access provide evidence on the actual contact individuals have with ICT and on what they can do with the support of these tools. From this perspective, it is important to study more specifically the context of ICT use and distinguish, for example, between individual and group access to ICT in schools.
- Today, computers are not the only educational technology being used and explored in schools. Other devices, such as personal or handheld devices (e.g. cellular phones, personal digital assistants (PDAs), game consoles or ultra-mobile PCs), are increasingly relevant in the educational context thanks to their “ubiquity”, *i.e.* the fact that they can be used in any location or context. It is therefore important to include these ICT technologies in international comparative surveys and to continuously update technologies as they evolve.

Key findings

- Almost all 15-year-old students in the countries surveyed have some experience with computers. In all of the OECD countries covered, the majority of students started using computers at least when they entered secondary education. Although on average the length of time during which students have been using computers has increased for OECD countries since PISA 2003, it differs greatly across and within countries.
- On average in OECD countries access to educational resources at home (computers for schoolwork, a link to the Internet, educational software and books for schoolwork) has increased since PISA 2003. The socio-economic background of students still plays a strong role, especially for educational resources related to information and communication technology (ICT), although the differences are decreasing thanks to a significant increase in the access of students in the bottom quarter.
- Inequalities across OECD countries in terms of access to resources for home study are similar for computers and for books, and in both cases these inequalities have decreased since PISA 2003. However, as access to computers for schoolwork lessens, books are relatively more important for schoolwork. Finally, for access to the Internet and educational software, the differences between the bottom socio-economic quarter and the top socio-economic quarter in OECD countries are larger than for computers and books for schoolwork.
- The great majority of students in all countries surveyed have some kind of access to computers at school and go to schools in which the great majority of computers are available for instruction. Nevertheless 12.06% of students on average in OECD countries declare that they *never use* these technologies at school.
- The number of students per computer in schools has increased since PISA 2000 and PISA 2003, but remains highly unequal across countries. In OECD countries the average is 0.19, nearly the same as in PISA 2003 but 0.1 higher than in PISA 2000.
- In 27 of 29 OECD countries more than 80% of computers in schools are connected to the Internet. There is much more variability across the partner countries that participated in the survey, with computers connected to the Internet ranging from 10% to 100%.

Notes

1. For more details on plausible values, please refer to the PISA 2006 Data Analysis Manual.
2. The SITES 2006 study (Law, Pelgrum and Plomp, 2008) is the third study carried by the International Association for the Evaluation of Educational Achievement (IEA), to learn how educational systems throughout the world have integrated ICT in education. SITES' 2006 major question was related to the impact of a ten-year period of investments in ICT in education, and more specifically, to the extent to which and how ICT is used in education and how it supports and enhances pedagogical practices. The 23 educational systems participating in this survey were: Canada (Alberta, Ontario), Chile, Chinese Taipei, Denmark, Estonia, Finland, France, Hong Kong (China), Israel, Italy, Japan, Lithuania, Norway, Russian Federation, Russia Moscow Region, Singapore, Slovak Republic, Slovenia, Spain (Catalonia), South Africa and Thailand.

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Chapter 3

Students' use of information and communication technologies and the role of confidence

Examination of the frequency and patterns of ICT use provides a picture of how students are taking advantage of the opportunities made available by ICT in schools and at home. Once they have access, types of ICT use depend on variables related to students' cognitive, cultural and socio-demographic characteristics. This chapter gives special attention to students' gender and socio-economic status and offers for the first time an analysis of user profiles that go beyond traditional stereotypes. It also presents a detailed analysis of students' attitudes to ICT and how they relate to performance in science.

Use of ICT in schools and at home

Chapter 2 discussed the notion of access to ICT and argued that it is not only a matter of availability of physical ICT resources but also of the conditions under which ICT resources are available for use for a specific purpose, such as learning. In other words, access to ICT is not only about having or not having certain ICT resources at home or at school, but also about actual opportunities to use them. As Chapter 2 demonstrated, for 15-year-old students these opportunities are still highly dependent on their socio-economic status.

The question of ICT use goes a step further to consider actual patterns of use. It goes beyond the opportunities available to people to look at how people interact with ICT or take advantage of the opportunities offered. From this standpoint, once an individual has the necessary conditions of access, the use made of the technology varies depending on a mix of factors, related mostly to the individual's cognitive, cultural and socio-demographic characteristics. This perspective gives rise to the notion of what has been called the "second-level digital divide" which refers not to differences in access but to differences in the capacity to use ICT and take advantage of them (Hargittai, 2002; Robinson, DiMaggio, and Hargittai, 2003). Chapter 4 will discuss how differences in use can result in differences in skills and learning outcomes (Peter and Valkenburg, 2007; Hargittai, 2002).

This section analyses patterns of students' ICT use at home and at school based on PISA 2006 data (Figure 3.1), in comparison, when possible, to PISA 2003 data, particularly for OECD countries. In order to understand some of the variables that may explain the different patterns, special attention is given to gender and to students' economic, social and cultural status (ESCS). In addition, confidence in using ICT is analysed. This variable appears related to a person's capacity to engage with or make meaningful use of ICT. Some analysts have started to stress that this seems to play a key role in how individuals use and take advantage of technology. As Selwyn (2004, p. 352) points out, engagement with ICT happens when an individual can exercise "a degree of control and choice over technology and content". This depends on several factors, such as social, cultural, economic, pragmatic and also psychological reasons. Among psychological reasons, confidence in using ICT, *i.e.* lack of anxiety, seems to play an important role.

Figure 3.1. Student computer use in OECD countries

Percentage of students on average in OECD countries who:

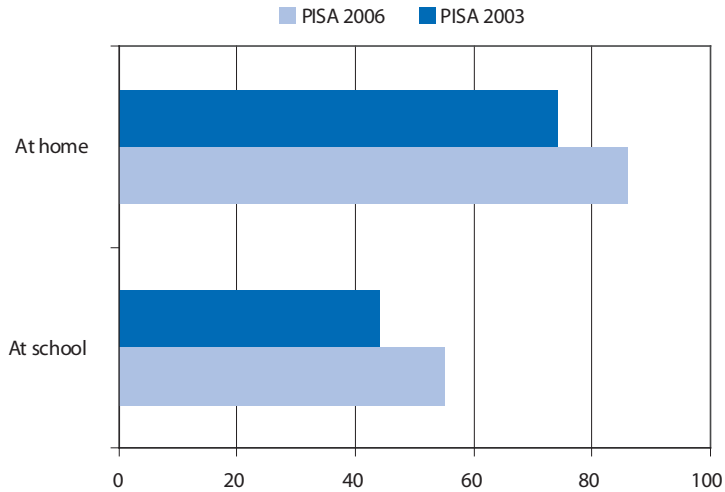
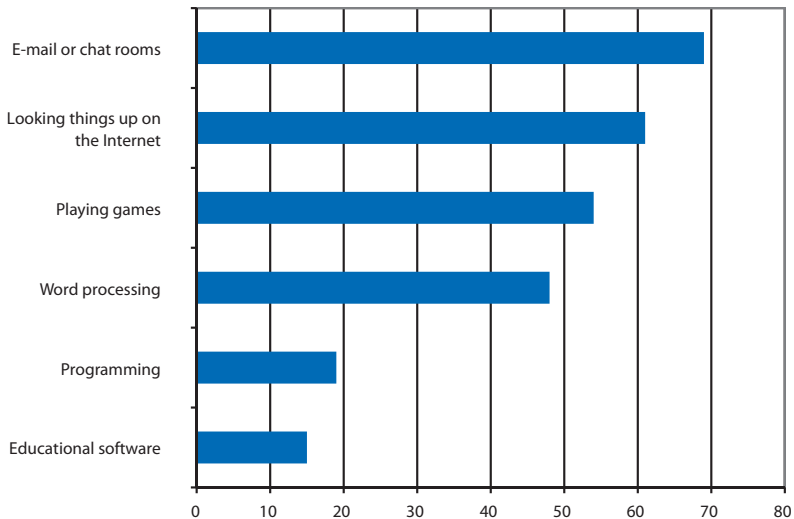
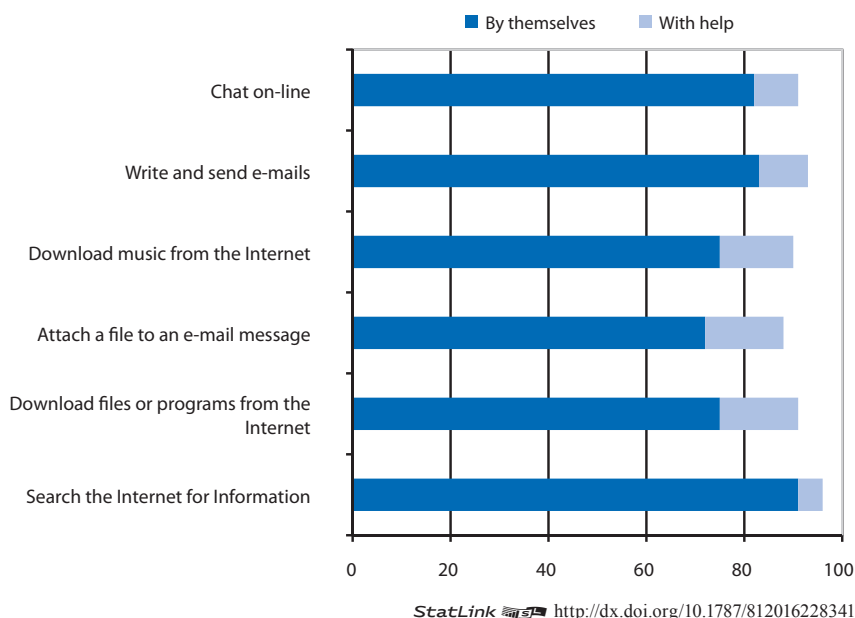
Figure 3.1a. Use computers frequentlyStatLink  <http://dx.doi.org/10.1787/812016228341>**Figure 3.1b. Percentage of students who use computers frequently for the following activities**StatLink  <http://dx.doi.org/10.1787/812016228341>

Figure 3.1c. Are confident that they can complete the following



Frequency of use by location

How often do students use computers and how does this vary by location?

Frequency of use by location is important as it provides an idea of the relative role of schools, homes and other locations of ICT use. Many studies show that, in general, computers and other ICT resources are used less at school than outside of school. Nevertheless, this should not lead to denying the educational relevance of ICT to the lives of the younger generations. Some studies have started to discuss and to find evidence that young people are learning new skills as a consequence of intensive out-of-school use of ICT, where individual or peer-to-peer use is most common (Sefton-Green, 2003). As a consequence, greater attention should be paid to out-of-school learning with ICT, and discussion of how educational institutions should integrate this learning into the curriculum should be encouraged (Pedró, 2007).

Like PISA 2003, PISA 2006 asked students how often they used a computer at home, at school or elsewhere. If students responded that they used computers almost every day or a few times each week, they were considered

frequent users of computers (Box 3.1). Figure 3.2 presents the results for all countries and shows the relative importance of homes as compared to schools among frequent ICT users in most participating countries. In all OECD countries except Hungary and in partner countries Bulgaria, Colombia, Jordan, Latvia, the Russian Federation, Serbia, and Thailand, students reported using computers most often at home. This was the case for three-quarters of students in 30 of the 40 surveyed countries. In the other countries, less than half reported using computers most frequently at home in Thailand and Colombia. In countries in which schools have a relatively higher percentage of frequent ICT users than homes, over 70% of students use computers frequently at school. Finally, less than two-fifths of students reported using computers frequently in other locations in most countries.

Since PISA 2003, frequent use increased on average among OECD countries in all three categories. Frequent use at school and at home increased similarly (11 and 12 percentage points, respectively) while frequent use in other places increased relatively less (4 percentage points) (Annex A, Table A.8). This suggests that although frequent use at home leads frequent use at schools in most countries, the gap does not seem to be widening. A matter worthy of further exploration is whether ICT use at home and ICT use at school influence each other in any way, for example, if there is any relation or continuity between ICT activities at school and those at home, and *vice versa*. More specifically, it would be important to know if the motivation for certain uses at home is related to school needs or if students and parents put pressure on schools and teachers to use ICT in certain ways at school. In this respect, students should be asked in subsequent surveys about the reasons for their uses and the locations in which they do various types of activity more frequently.

Box 3.1. Student responses on frequency of use and how they were classified

In order to maintain consistency and comparability with the PISA 2003 report (OECD, 2006), the five possible responses related to frequency of use were grouped into the same three categories:

Frequent use:

“Almost every day” or “A few times each week”

Moderate use:

“Between once a week and once a month”

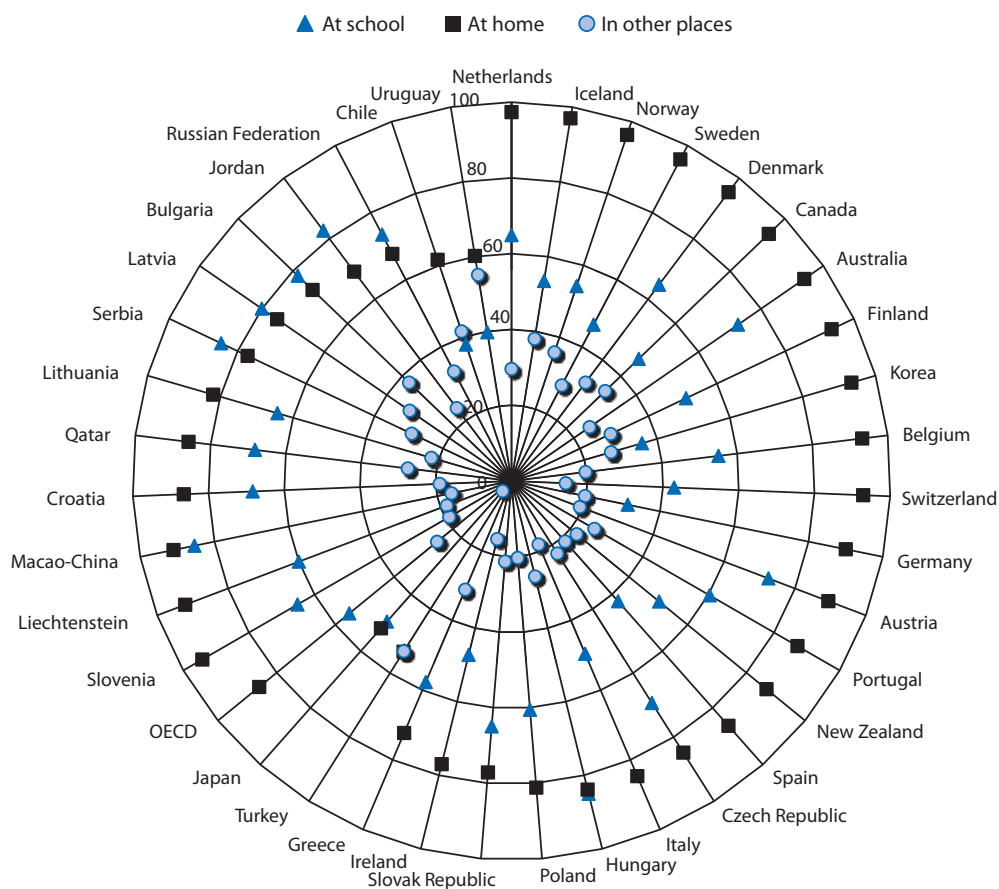
Rare or no use:

“Less than once a month” or “Never”

Frequency of use by type of use

Having asked students how much they used computers overall at home and at school, the survey asked 11 questions about how frequently they used computers to perform various types of functions. This gives a general picture of the patterns of ICT use 15-year-old students who are frequent users and also about the ICT-related skills they may develop in this way. In order to summarise the results, an index of frequency was constructed for each of two groups of usage, composed of six and five types of ICT functions, respectively. The first index

Figure 3.2. Students frequently using a computer at home, school or other places



StatLink  <http://dx.doi.org/10.1787/812051880261>

Moving clockwise, countries are ranked in descending order of percentage of students frequently using computers at home. OECD and partner countries are grouped separately.

Source: OECD PISA 2006 Database.

is for Internet and entertainment tasks and incorporates educational uses, such as looking up information, and leisure uses, such as playing games. The second index is for the use of programmes such as word processing or spreadsheets and the use of educational software. Box 3.2 explains their interpretation.

Box 3.2. Interpreting the indices of frequency of ICT usage

Each index comparing how much use different students make of a range of ICT functions combines their responses to several questions into a composite score. These scores are represented as index numbers so that on each index the average score for all students in all OECD countries is zero, and about two-thirds of students score between +1 and -1. For example, a score of -1 indicates that a student uses computers more than about one-sixth of students internationally, and a score of +1 that he/she uses computers more than about five-sixths of students. Each index is self-contained: it is designed only to show the relative amount of use made of that particular set of computer functions by different groups of students. Comparing a country's mean on one index to its mean on the other index does not allow concluding that students in that country use the set of computer functions more frequently in the index with the higher score. To compare frequency of use of each index Tables 3.1 and 3.2 show the percentage of students in each country reporting frequent use of each computer function included in the index.

Frequency of ICT Internet and entertainment use

Students were asked how frequently they perform various Internet and entertainment tasks using ICT. As discussed in Chapter 2, Internet use is relevant for accessing information and educational resources. Furthermore, Internet recreational and communication activities are at the core of the so-called digital culture, and an important issue is whether some groups are left behind or excluded from this culture. The activities included in the PISA questionnaire were: play games, download software from the Internet (including games); download music from the Internet, browse the Internet for information about people, things or ideas; use the Internet to collaborate with a group or team; and use the Internet for communication (e.g. e-mail or chat rooms).

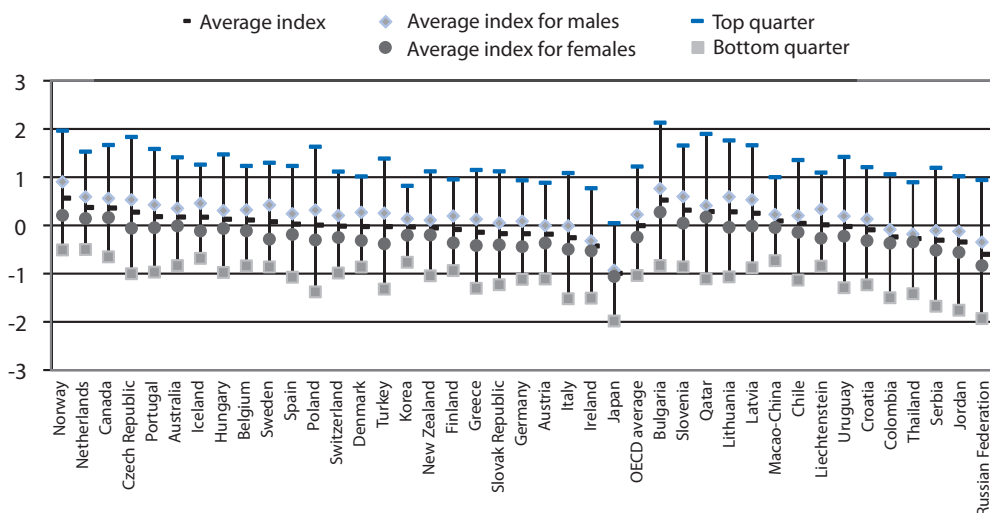
Looking first at the average index across the Internet and entertainment activities, students' use of ICT for these purposes is highest (over 0.25) in Canada, the Czech Republic, the Netherlands and Norway and in partner countries Bulgaria, Latvia, Lithuania, Qatar and Slovenia (Figure 3.3). The lowest use of computers for these purposes (under -0.25) is in Italy, Ireland and Japan and in partner countries Jordan, the Russian Federation, Serbia and Thailand. Compared to the OECD average index (-0.01), that of Japan is particularly low (-0.99) (Figure 3.3).

It is also possible to compare countries in terms of the gap between those who use ICT the most and the least. Figure 3.3 indicates this by the symbols that represent use by the quarter of students with the most use of ICT for the Internet and entertainment and the quarter with the least use. The widest gaps between these groups (2.6 index points or more) are in the Czech Republic, Italy, Poland and Turkey and in partner countries Bulgaria, Jordan, Lithuania, Qatar, the Russian Federation, Serbia and Uruguay, while the smallest gaps (2 points or less), that is, the most even use across the population, are in Austria, Denmark, Finland, Iceland and Korea and in partner countries Liechtenstein and Macao, China.

Specific types of Internet and entertainment use

On average across OECD countries, more than 60% of students frequently use their computers for e-mail or chatting (69%) and to look up information about people, things or ideas on the Internet (61%). More than 50% frequently use them to download music (58%) and play games (54%), and the smallest percentage of frequent use is to download software (41%) and to collaborate with a group or team (37%). Compared to PISA 2003, the average percentage of 15-year-old students' use of all types of use classified here

Figure 3.3. **Index of ICT Internet and entertainment use**



StatLink <http://dx.doi.org/10.1787/812077025432>

Countries are ranked in descending order by average index. OECD and partner countries are grouped separately.

Source: OECD PISA 2006 Database.

as Internet and entertainment has increased. In particular, computer use for e-mail or chatting rose by 13 percentage points and for downloading music by 9 percentage points. Looking up information about people, things or ideas on the Internet and collaborating with a group or team both rose by 6 percentage points. Computer use to download software increased by 3 percentage points and playing games by just 1 percentage point.

The results for individual countries for each activity are listed in Table 3.1. In some countries more than two-thirds of students use computers for some of these purposes. This is true in the majority of OECD countries for e-mail and chatting, where at least two-thirds of students reported doing so frequently in 18 of the 25 participating countries. Two-thirds or more use the Internet to look things up in Australia, Canada, Iceland, Korea, the Netherlands, Norway and Portugal, and as many frequently download music in Belgium, Canada, the Netherlands, Norway and Spain and in partner country Bulgaria. Country comparisons show that Iceland, the Netherlands and Norway stand out in the use of Internet for communication; with at least 90% of students reporting using the Internet for e-mail and chatting. In most countries less than half of students use the Internet to collaborate with a group or team or to download software. Japan has the lowest percentage (less than 30%) of use in each type of Internet and entertainment use.

Table 3.1. Students' use of ICT for Internet and entertainment

Index of ICT Internet and entertainment use

	Browse the Internet for information about people, things or ideas	Play games	Use the Internet to collaborate with a group or team	Download software from the Internet (including games)	Download music from the Internet	A computer for electronic communication (e.g. e-mail or chat rooms)
Norway	78	59	65	55	55	90
Netherlands	67	64	39	51	51	92
Canada	71	57	52	48	48	86
Czech Republic	69	56	56	45	45	71
Portugal	76	59	60	48	48	69
Australia	72	49	48	48	48	80
Iceland	76	56	26	40	40	90
Hungary	62	66	54	42	42	68
Belgium	56	53	40	45	45	84

Table 3.1. **Students' use of ICT for Internet and entertainment**

Index of ICT Internet and entertainment use

(continued)

	Browse the Internet for information about people, things or ideas	Play games	Use the Internet to collaborate with a group or team	Download software from the Internet (including games)	Download music from the Internet	A computer for electronic communication (e.g. e-mail or chat rooms)
Sweden	66	53	23	44	44	85
Spain	66	57	26	42	42	75
Poland	54	53	43	42	42	56
Switzerland	60	43	33	44	44	79
Denmark	63	56	34	38	38	79
Turkey	55	57	46	49	49	61
Korea	68	54	25	40	40	66
New Zealand	63	47	39	38	38	68
Finland	57	57	18	38	38	85
Greece	57	66	27	50	50	40
Slovak Republic	47	59	41	32	32	57
Germany	54	52	33	33	33	70
Austria	54	48	30	36	36	70
Italy	57	56	22	46	46	45
Ireland	53	45	26	30	30	43
Japan	30	21	9	13	13	22
Chile	66	56	48	39	39	70
OECD average	61	54	37	41	41	69
Bulgaria	64	69	49	70	70	79
Slovenia	50	56	74	55	55	76
Qatar	70	66	53	59	59	62
Lithuania	59	59	66	52	52	72
Latvia	62	52	47	54	54	81
Macao, China	66	60	24	56	56	75
Liechtenstein	58	44	29	44	44	84
Uruguay	67	52	47	38	38	69

Table 3.1. **Students' use of ICT for Internet and entertainment**

Index of ICT Internet and entertainment use

(continued)

	Browse the Internet for information about people, things or ideas	Play games	Use the Internet to collaborate with a group or team	Download software from the Internet (including games)	Download music from the Internet	A computer for electronic communication (e.g. e-mail or chat rooms)
Croatia	51	65	37	43	43	50
Colombia	63	46	43	42	42	52
Thailand	63	50	50	36	36	45
Serbia	37	74	29	42	42	42
Jordan	50	63	41	40	40	37
Russian Federation	34	65	27	34	34	31

Countries are ranked in descending order by average index. OECD and partner countries are grouped separately.

Source: OECD PISA 2006 Database.

Frequency of use of ICT for programmes and software

Students were also asked how frequently they use ICT for different programmes and software. There were five possible answers: writing computer programmes; using educational software such as mathematics programmes; drawing, painting or using graphic programmes; using spreadsheets (e.g. <Lotus 123® or Microsoft Excel®>) and write documents (e.g. with <Word®> or <WordPerfect®>). The programmes and software explored were those most commonly used for schoolwork activities. Figure 3.4 uses an index to compare average student use for these purposes. As for PISA 2003 data overall, considerably fewer students reported frequent use of programmes and software than use of ICT for the Internet and entertainment: a minority of students on average used computers frequently for any one of these purposes except writing documents (Table 3.2). The index values are adjusted so that on each index the OECD average is zero; therefore a given score on the programmes and software index represents a lower average frequency than on the Internet and entertainment index. In Portugal and Turkey and in partner countries Bulgaria, Colombia, Jordan, Thailand and Uruguay, students report comparatively high use of programmes and software. Students in Finland, Iceland, Ireland, Japan and Korea and in partner economy Macao, China, report comparatively low use. Deeper exploration of this issue by countries would be interesting, for example to see if countries with relative high use of programmes and software have developed specific educational policies to encourage their use.

Table 3.2. Students' use of ICT for programmes and software

	Writing computer programmes	Use educational software such as mathematics programmes	Drawing, painting or using graphic programmes	Use spreadsheets (e.g. <Lotus 123® or Microsoft Excel®>)	Write documents (e.g. with <Word®> or <WordPerfect®>)
Turkey	36	36	47	36	57
Portugal	19	27	46	34	68
Greece	38	30	44	27	46
Hungary	31	18	32	37	54
Norway	35	12	28	19	58
Poland	23	26	37	27	44
Czech Republic	23	21	30	26	46
Australia	12	13	37	22	72
Spain	35	15	32	24	53
Italy	31	22	31	25	51
Austria	15	12	31	27	62
Slovak Republic	23	20	32	26	47
Canada	16	10	36	17	58
Germany	15	15	26	20	52
Switzerland	15	11	27	21	50
New Zealand	11	13	32	22	49
Denmark	10	11	23	17	60
Netherlands	13	10	25	16	61
Belgium	15	10	26	17	49
Iceland	12	11	23	10	36
Sweden	11	5	28	9	35
Finland	12	3	28	8	25
Korea	7	14	18	9	30
Ireland	11	13	27	13	28
Japan	5	2	10	10	15
Chile	25	26	38	31	58
OECD average	19	15	30	21	48
Jordan	48	43	52	39	55
Qatar	43	39	50	42	52
Colombia	40	36	50	35	65

Table 3.2. **Students' use of ICT for programmes and software** (*continued*)

	Writing computer programmes	Use educational software such as mathematics programmes	Drawing, painting or using graphic programmes	Use spreadsheets (e.g. <Lotus 123® or Microsoft Excel®>)	Write documents (e.g. with <Word®> or <WordPerfect®>)
Bulgaria	25	38	49	44	48
Thailand	28	32	41	43	59
Uruguay	28	50	37	38	58
Latvia	22	25	40	35	44
Lithuania	32	27	36	28	43
Russian Federation	24	36	43	31	50
Slovenia	22	15	38	26	49
Croatia	25	23	47	26	48
Serbia	20	21	55	26	48
Liechtenstein	13	9	30	18	56
Macao, China	14	12	19	12	28

Countries are ranked in descending order by average index. OECD and partner countries are grouped separately.

Source: OECD PISA 2006 Database.

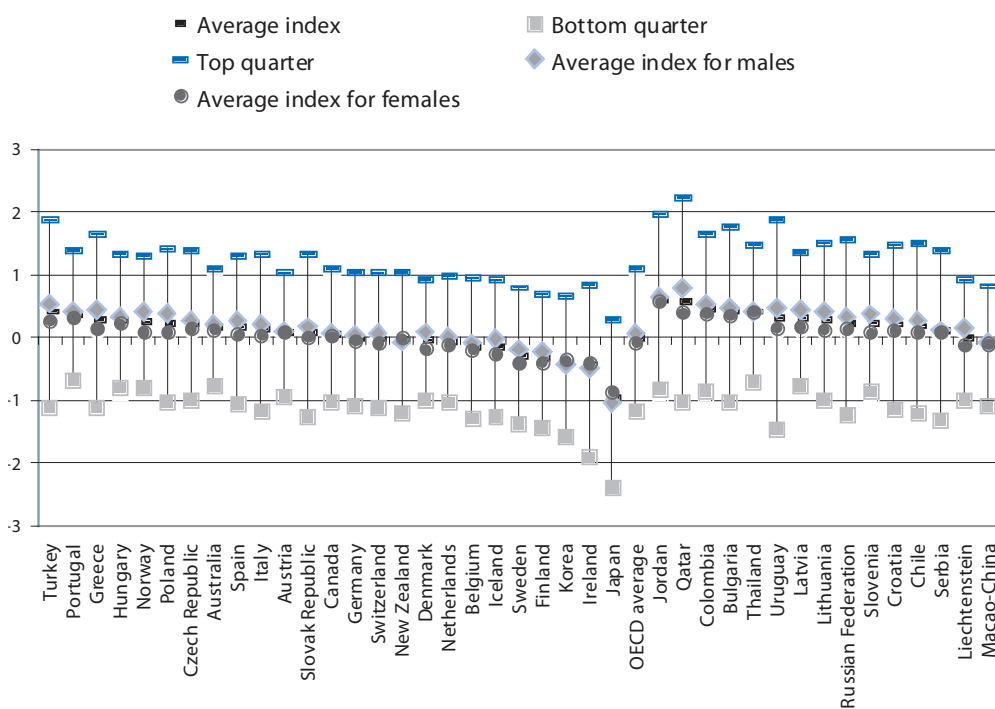
Also, the range of reported use of ICT for programmes and software within countries varies, revealing more or less homogeneity within the 15-year-old student population. For example, wider differences (of at least 2.8 index points) between students in the top and bottom quarters of the index are found in Turkey and in partner countries Bulgaria, Qatar, the Russian Federation and Uruguay. More homogeneity (range of 2.0 index points or less) between the top and bottom quarters is observed in Australia, Austria and Denmark and in partner countries Liechtenstein and Macao, China (Figure 3.4).

Word processing (e.g. <Microsoft Word®> or <WordPerfect®>) was frequently used by the highest percentage of students on average in OECD countries (48%), ranging from 15% of students in Japan to 72% in Australia. In the majority of OECD countries between 40% and 60% of students reported frequent use of word processing software (Table 3.2), an average of 30% reported frequent use of drawing, painting or graphics programmes, 21% frequent use of spreadsheets (e.g. <Lotus 123® or Microsoft Excel®>), 19% writing computer programmes and only 15% educational software such

as mathematical programmes.¹ Over 30% of students reported frequent use of the computer for programming in Greece, Hungary, Italy, Spain and Norway, and over 30% frequently used spreadsheets in Hungary, Portugal and Turkey.

Out of all 12 ICT uses that students were asked about in the survey, the one that fewest reported using frequently was educational software, such as mathematics programmes (15%), the same percentage as in PISA 2003. However, in partner countries Jordan and Uruguay, 43% and 50%, respectively, reported frequent use of educational software.

Figure 3.4. **Index of ICT programme and software use**



StatLink <http://dx.doi.org/10.1787/812122871673>

Countries are ranked in descending order by average index. OECD and partner countries are grouped separately.

Source: OECD PISA 2006 database.

Gender differences in frequency of use of ICT for the Internet and entertainment and for programmes and software

As in PISA 2003, in all countries participating in PISA 2006, males use ICT more than females for Internet and entertainment (Table A.9). Consistent with PISA 2003 data and with other studies (Kirriemuir and McFarlane, 2004), the most pronounced gender differences are in reported use of computer games. On average in OECD countries, males are twice as likely as females to play such games frequently (72% and 35%, respectively). In Denmark and Sweden, the gap is even wider, with more than 50 percentage points of difference. In Greece, where the gender gap is narrower (23%), over one-half of females aged 15 frequently use computers for games (this was the case for the United States in PISA 2003). On average across OECD countries, males are also twice as likely to download software from the Internet (including games) frequently (males 54% and females 27%). The difference between males and females is much smaller for downloading music from the Internet (64% and 52% respectively), browsing the Internet for information (63% and 59% respectively), using the Internet to collaborate (41% and 32% respectively). They make similar use of computers for electronic communication, with an average of 69% of males and 70% of females reporting frequent use of computers for this purpose. These gender differences are in all uses very similar to those observed in PISA 2003.

For use of ICT for programmes and software, males report the most frequent use in the majority of countries, although the difference in the mean index for females and males decreased 0.7 points since PISA 2003. Here, the gender gap is on average less than half as wide as for Internet and entertainment. As in PISA 2003, in Ireland, Japan and Korea and now also in New Zealand, a higher percentage of females report more frequent use (Figure 3.4). In OECD countries almost twice as many males report frequent use of computers for programming: 23% of males and 14% of females on average, a decrease from 30% and 16%, respectively, in PISA 2003. The gender difference is particularly large in Denmark, Finland and Iceland, where males are three times as likely as females to use computers frequently for programming. Compared to PISA 2003 data, which showed males in Finland nearly six times more likely to do so, these differences have decreased to half. However, gender differences for other programmes and software uses are not very pronounced. In OECD countries, a higher percentage of females use word processing frequently (50% compared to 46% among males). As in PISA 2003 they tend to increase countries' average for frequent users of word processing (the highest percentages of frequent users of word processing by country are mainly those in which females use them more).

The former results are consistent with national studies that show that males use ICT for a wider range of activities and are more likely to use

them for leisure purposes. They also show that females' leisure use of ICT is more likely to be for communication and that they tend to use ICT more for schoolwork than males. Additionally, some of these studies also show that females are generally less confident when using ICT (Looker and Thiessen, 2003; Valentine and Pattie, 2005; Todorova *et al.*, 2008). Although these findings are very consistent both with national studies and with PISA 2003 data, they should be interpreted with caution. PISA data regarding ICT use is based on students' self-reports, and recent studies have shown that youngsters tend to respond to questions regarding their ICT use according to what they consider appropriate behaviour in terms of gender-dominant discourse and stereotypes, not necessarily what they actually do (Carr, 2005). These views are communicated by parents, peers, schools and the mass media and include gender stereotypes and a strong link between masculinity and technology (Corneliussen, 2003; Gansmo, 2004; Tønnessen, 2007; Vekiri and Chronaki, 2008). As the profile analyses discussed below will show, the picture is more nuanced, with groups of boys and girls relating differently to ICT depending not only on gender but also on their background and individual characteristics.

Socio-economic differences in frequency of use of ICT for the Internet and entertainment and of ICT for programmes and software

On average among OECD countries there is a difference between the top and bottom ESCS quarters of 0.45 in the index means for Internet and entertainment. The difference is smallest for playing games (0.09) and largest for use of Internet for communication (*e.g.* e-mail and chat rooms) (0.78). In the programmes and software index the difference is half that for the Internet and entertainment (0.23 and 0.45 index means, respectively). The difference is greatest for writing documents (0.47) and smallest for writing computer programmes (0.02).

Students' confidence in using ICT

As in PISA 2003, in PISA 2006 students provided information on how well they felt they could perform various tasks using a computer. As mentioned above, this seems to play an important role in an individual's engagement with ICT. Two categories were included in the analysis: Internet tasks and high-level tasks. When interpreting the results it is important to bear in mind that the indices of confidence in using ICT are based on students' subjective assessments and that students in different countries may perceive and respond to questions differently.

Students' confidence in performing different computing tasks

What can students do with a computer? PISA 2006 asked students how well they could perform 14 different ICT tasks. There were four possible answers (I can do this very well by myself; I can do this with help from someone; I know what this means but I cannot do it; and I don't know what this means). Students are here considered to be at least somewhat confident in performing a task if they answered "I can do this with help from someone" and to have high level of confidence if they answered, "I can do this very well by myself" (Table 3.3). The questions identified two broad groups of tasks: Internet tasks and high-level tasks. Two indices were derived from these.

Generally, students in all participating countries report high confidence in using ICT, with the majority saying they are able to perform 9 of the 14 tasks specified very well by themselves. As expected, students are relatively more confident performing Internet tasks than high-level tasks, although even in the case of the latter, most students thought that they could do each task if they had some help.

Table 3.3. Percentage of students reporting how well they can perform Internet tasks and high-level tasks on a computer (OECD average)

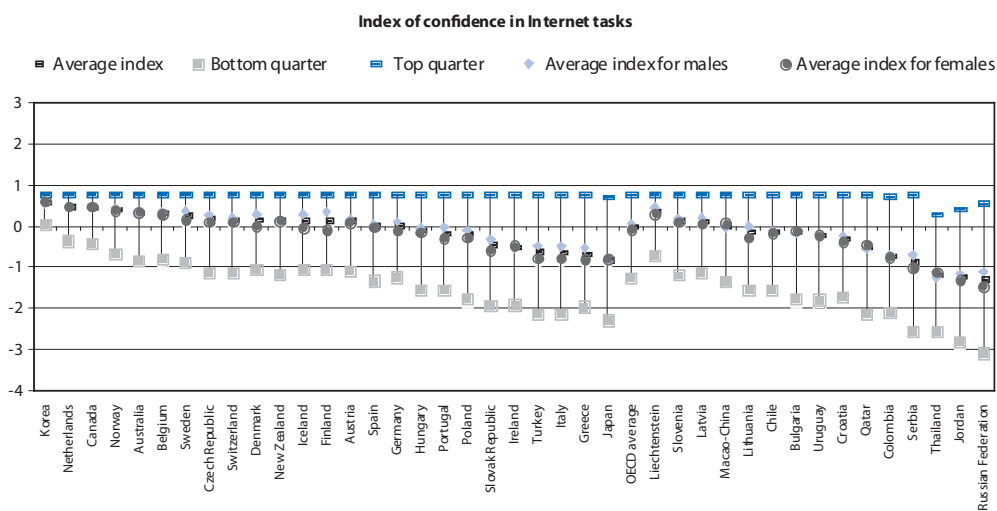
	Yes	Yes with help
Internet task		
Search the Internet for information	91	5
Download files or programmes from the Internet	75	16
Attach a file to an e-mail message	72	16
Download music from the Internet	75	15
Write and send e-mail	83	10
Chat on line	82	9
High-level ICT tasks		
Use software to find or get rid of viruses	44	29
Create a database (e.g. using < Microsoft Access ® >)	25	31
Edit digital photographs or other graphic images	58	26
Use a spreadsheet to plot a graph	48	31
Create a presentation (e.g. using <Microsoft® PowerPoint®>)	58	25
Create a multimedia presentation (with sound, pictures, video)	44	35
Construct a web page	31	38
Use a word processor (e.g. to write an essay for school)	82	11

Internet tasks

Figure 3.5 shows that students are most confident (over 0.40 mean index) in performing Internet tasks in Canada (0.47), Korea (0.59), the Netherlands (0.49) and Norway (0.41). In these countries at least 90% of students report being confident to do each of the six Internet tasks. Conversely, students in partner countries Jordan (-1.23), Russian Federation (-1.30) and Thailand (-1.17) have the lowest levels of reported confidence in Internet tasks. Korea has the highest mean on the index of confidence in ICT Internet tasks, although it decreased from 0.77 in PISA 2003 to 0.59 in PISA 2006. However, as in PISA 2003 this contrasts with reported means on the index of confidence in high-level tasks (-0.24), which is below the OECD average. For Internet tasks, students in OECD member countries report the highest confidence on average in searching the Internet for information, writing and sending e-mail, and chatting on line (Table 3.3).

Figure 3.5. Indices of students' confidence with Internet tasks and high-level tasks

Figure 3.5a

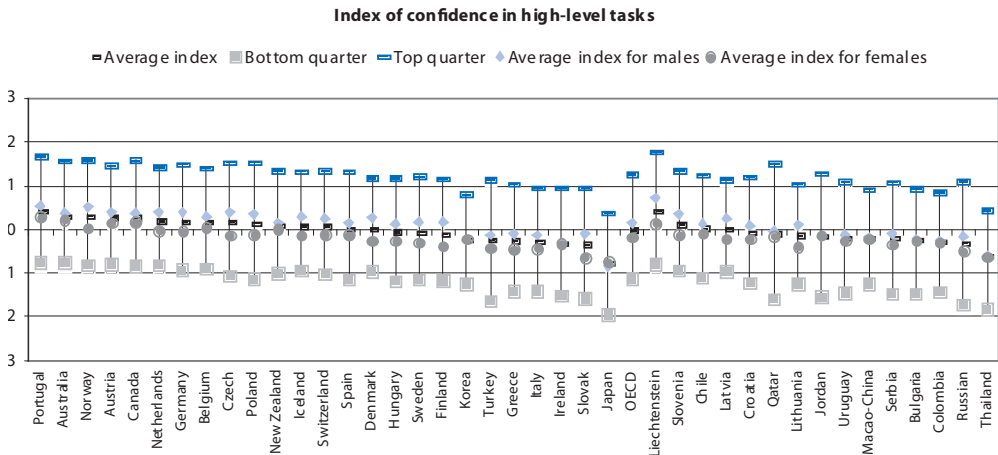


StatLink <http://dx.doi.org/10.1787/812145510214>

Countries are ranked in descending order by average index. OECD and partner countries are grouped separately.

Source: OECD PISA 2006 Database.

Figure 3.5b



StatLink  <http://dx.doi.org/10.1787/812145510214>

Countries are ranked in descending order by average index. OECD and partner countries are grouped separately.

Source: OECD PISA 2006 Database.

High-level tasks

In all participating countries students are, as expected, comparatively less confident in performing high-level tasks on a computer. On average the task that students are least confident performing is creating a database (25%). However, over one-half of students in OECD countries (56%) still report that they can do this either by themselves or with help from someone (Table 3.3). Comparatively more students (over a mean index of 0.20) in Australia, Austria, Canada, the Netherlands, Norway and Portugal and in partner country Liechtenstein report being confident performing high-level tasks on a computer (Figure 3.5).

Gender differences

There are quite clear gender differences in the indices of confidence in Internet tasks and high-level tasks. In the majority of countries, males report higher confidence in both categories (Figure 3.5). Even though differences in favour of males are greater for confidence in performing high-level tasks, Japan and Korea and partner country Jordan are exceptions. Since PISA 2003 the average OECD difference in confidence in high-level tasks has decreased significantly (0.17 index points). The countries with the highest gender difference (over 0.40 index points) are the Czech Republic (0.54), Denmark (0.53), Finland (0.57), Germany (0.42), Iceland (0.45), Norway (0.50), Poland (0.47),

the Slovak Republic (0.57) and Sweden (0.48), and partner countries Latvia (0.46), Liechtenstein (0.59), Lithuania (0.52) and Slovenia (0.48).

A closer look at students' self-reported levels of confidence for high-level computer tasks offers some insight into where gender differences are most and least important. On average in OECD countries, a higher percentage of males report being confident in all tasks in this category except use of a word processor, for which the percentage of females is slightly higher. The greatest gender differences (more than 10 percentage points) are found for use of software to find or get rid of viruses (19 percentage points) and creation of a database (11 percentage points). For all the other tasks the difference is less than 8 percentage points. The tasks more likely to be used in an academic context – use a word processor, create a presentation, and use a spreadsheet to plot a graph – have less than 5 percentage points of difference.

Proposal for a collection of user profiles: students' ICT use profiles

Introduction

This section explores how students use ICT in order to develop a set of student profiles. Student profiles represent one way to characterise different segments of the student population and make it possible to describe, compare and discuss differences and similarities among various segments. They can also provide a nuanced picture of what young people aged 15 do with ICT. The profiles classify students in different groups according to their amount and type of ICT use.

In terms of types of ICT use, the questionnaire covers eight possible options: “browse the Internet”, “play games”, “download software”, “download music”, “e-mail and chat rooms”, “write documents”, “use spreadsheets”, and “educational software”. To create meaningful ICT user profiles, these eight categories were collapsed into two broad types of ICT use: “leisure use”² and “educational use”.³ The distinction was made based on previous descriptions of ICT use (e.g. the distinction between ICT Internet/entertainment use and ICT programme/software use) and empirical identification of consistent patterns in the material.

In addition to the different types of ICT use, students were also asked the frequency of these various types of ICT use. The options were “almost every day”, “once or twice a week”, “a few times a month”, “once a month or less” and “never”. When developing the profiles, the answers to the variables defining “leisure use” and “educational use” were recoded by collapsing results. Then, a new classification of “frequency” was developed to reduce the number of available option and obtain more distinctive user profiles.

This new classification ranges from “frequent” to cover the span from those who answered “almost every day” to those who answer “once or twice a week” to each question (as average score); “monthly” consisting of students who answer “a few times a month”; and the group “rare” composed of those answering “once a month or less” and “never” to individual questions.

Furthermore, the ICT questionnaires make it possible to include in the profiles background characteristics of the students such as gender, socio-economic background, interest in and performance in science. This can then help go beyond stereotyped views of young people’s use of and attitudes towards ICTs, such as “the gaming boy” and “the communicating girl”.

The next section presents the different ICT user profiles identified using the classification of ICT users according to the frequency of different uses.

Student profiles: distribution, frequencies and definition of the profiles

The profiles presented here derive from a combination of the scores of two variables for type of ICT use (educational and leisure use) and three categories of frequency of use (rare, monthly and frequent).

This combination of variables gives nine different potential profiles. Table 3.4 shows the percentage of students for each of these profiles.

Table 3.4. Distribution of students in the nine profiles

	Rare educational	Monthly educational	Frequent educational	Total
Frequent leisure	19.7 %	6.4 %	6.9 %	33 %
Monthly leisure	18.6 %	3.9 %	2.1 %	24.6 %
Rare leisure	37.7 %	3.2 %	1.5 %	42.4 %
Total	76 %	13.5 %	10.5 %	100 %

As the table shows, 76% of students report rare use of ICT for educational purposes. Only a minority of students report frequent educational use of ICT. In terms of leisure use of ICT, almost a third of students report frequent ICT use. However, rare leisure use remains the larger category, accounting for 42.4% of students. These results are in line with results from other recent studies reporting on youngsters’ use of ICTs for educational purposes which have found that young people are more likely to use more varied and advanced types of ICT at home than at school (Beltran, Das and Fairlie, 2008; Lenhart *et al.*, 2008; Meelissen, 2008; Ofcom, 2008; Arnseth *et al.*, 2007; Pedró, 2007).

The nine profiles show the variations in frequencies of use of computers and in the self-reports on different types of ICT-related activities by 15-year-olds in OECD countries. However, not all of the nine profiles are sufficiently clear since they include combinations of answers covering variations in frequencies. For this reason, only six of them⁴ are considered to be the most promising and distinctive profiles. They were chosen for several reasons: four are combinations of frequent and rare use (corner positions) and are expected to be consistent and clear. One is selected because it has a middle position (monthly education and monthly leisure). The sixth profile (the combination of rare educational and monthly leisure) was selected because it contained a large number of students (almost 19% of all students). The names given to the six profiles are indicated in Table 3.5.

Table 3.5. **Student profiles**

	Rare educational	Monthly educational	Frequent educational
Frequent leisure	Digi-wired		Digi-zapper
Monthly leisure	Digi-casual	Digi-sporadic	
Rare leisure	Analogue		Digi-educational

The different profiles can be described as follows:

- *Digi-wired* report frequent use of leisure activities that require an Internet connection. This is the second largest profile (19.7% of all students) and it is male-dominated. Moreover, the level of ICT self-confidence (both Internet and high-level tasks) is higher than the standardised self-confidence average for the OECD student population. Both the socio-economic score and the performance in science score are above the standardised average scores for the OECD student population.
- *Digi-educational*s are students with low leisure use, who reported “once a month or less” or “never” in the questionnaire on issues related to “leisure use”, in combination with frequent educational use of ICT (answering “almost every day” and “once or twice a week” to questions on educational use). This profile includes a small share of students (1.5%). The profile is female-dominated. Self-confidence in ICT Internet tasks is below the average score for the OECD student population and self-confidence in ICT high-level tasks is above the average for the OECD student population. Both the socio-economic score and the performance in science scores are below the average scores for the OECD student population.

- *Digi-zappers* are students who report both frequent leisure use and frequent educational use (6.9% of all students). They use a variety of ICT programmes frequently. This may indicate that they switch between different software and applications. This profile is male-dominated with above average self-confidence in ICT (both Internet and high-level tasks) compared to the OECD student population. However, this profile scores below average for the socio-economic score and for performance in science.
- *Analogues* are uninterested in educational and leisure use. They are the opposite of digi-zappers. This is the largest profile (37.7% of all students). The label indicates that these students are more analogue than digital in their educational and leisure activities. This profile is female-dominated, with below average self-confidence in ICT (both Internet use and high-levels tasks), below average socio-economic scores, but above average performance in science.
- *Digi-sporadics* are students with monthly use of ICT for “leisure use” and for “educational use”. The profile is rather small (3.9% of all students). It is not very transparent because it can include students answering monthly use and students with a variety of combinations of frequent and low scores on single questions (e.g. writing documents almost every day and rare use of spreadsheets). There are slightly more females than males in this group.
- *Digi-casuals* are important because this profile represents almost one out of five students (18.6%). The profile includes students having a score defined as monthly for “leisure use” and students answering “almost every day and “once or twice a week” to questions defining educational use. This profile is less distinctive than some others, because students in the monthly leisure use category may have various answers to individual questions about leisure activities (e.g. almost every on some questions and rarely on others). This profile is female-dominated. Moreover, this profile has an above average socio-economic score and performs well in science.

The profiles show differences in the use of ICT, in terms of frequency and preferences for leisure use and school use. This set of profiles does not necessarily exclude the possibility of identifying other profiles in the PISA and ICT data.⁵ However, they appear quite robust and they relate differently to gender, socio-economic background and performance in science. These variations are further examined below.

At this point, it is important to see if there are differences across countries in the shares of students belonging to the different profiles. Table 3.6 presents the country distribution of students in these six profiles.

As Table 3.6 shows, there are large differences across countries in the distribution of the different profiles. The most *analogues* are in Japan and the fewest in the Netherlands. The most digi-educational are in Portugal and the fewest in Sweden. The most digi-casuals are in Korea and the fewest in Japan. The most digi-wired are in the Netherlands and the fewest in Japan. The most digi-zappers are in Turkey and the fewest in Japan.

Table 3.6. **Percentage distribution of students in the six profiles in each country**

Country	Profiles					
	Analogue	Digi-educational	Digi-casual	Digi-sporadic	Digi-wired	Digi-zapper
Australia	22.6	1.4	22.9	5.7	23.7	8.1
Austria	36.1	2.3	20.2	5.9	14.9	5.2
Belgium	24.6	0.6	27.2	3.5	29.0	5.3
Canada	17.8	0.5	25.9	3.4	34.1	7.4
Czech Republic	26.2	1.4	17.5	4.4	23.6	10.5
Denmark	32.6	1.2	23.9	4.3	20.4	6.0
Finland	34.0	0.2	27.0	1.4	30.9	1.7
Germany	38.5	1.9	19.2	5.2	17.3	4.7
Greece	34.2	2.4	16.8	5.5	14.4	13.1
Hungary	28.0	2.1	18.0	5.8	18.8	10.6
Iceland	20.7	0.2	27.5	3.3	34.3	4.6
Ireland	51.8	1.5	19.5	2.6	14.8	3.2
Italy	35.8	3.0	14.5	4.0	19.5	8.0
Japan	78.9	0.3	10.3	1.2	6.0	1.0
Korea	26.7	0.3	32.3	3.3	27.5	3.2
Netherlands	13.5	0.4	25.8	3.3	38.3	6.4
New Zealand	32.3	2.2	22.5	5.1	19.0	6.2
Norway	13.8	0.4	22.9	4.2	37.0	8.4
Poland	33.8	2.9	12.6	4.6	18.2	10.6
Portugal	25.2	3.2	15.1	6.1	16.9	13.4
Slovak Republic	42.2	2.5	14.9	5.6	12.1	8.7
Spain	25.2	1.8	19.2	3.6	29.8	8.0
Sweden	29.6	0.2	25.9	1.4	34.1	3.1
Switzerland	31.0	1.1	23.3	3.9	22.8	5.6
Turkey	32.3	2.8	13.2	6.1	11.1	17.0

Despite these disparities, most OECD countries have some common features. In particular, three profiles, *i.e.* analogue, digi-casual and digi-wired (all combining the leisure use category with low educational use) are among the most prevalent in almost every country. Exceptions are Japan, where the majority are analogue, Turkey, where digi-zappers exceed digi-wired and Greece where digi-zappers are almost as frequent as digi-wired. It is difficult to explain the different distributions across countries, and this calls for more research; nevertheless, this information allows countries to compare their positions with those of other countries.

A more nuanced picture of student profiles

As mentioned earlier, the background information in the questionnaires gives rise to a more nuanced picture of student profiles. The next sections analyse in more depth the characteristics of the different profiles in terms of gender, socio-economic background, attitudes to ICT and relation to educational performance. In doing so, this study complements the initial conclusions on the role of these factors presented in the previous section and serves as a bridge to Chapter 4, which explores the relation between ICT and educational performance.

Gender and student profiles

As previously stated, gender differences are apparent in terms of ICT both at school and elsewhere. Numerous studies, both qualitative and quantitative, report on differences in performance, patterns of use and attitudes towards ICT (Lenhart *et al.*, 2008; Meelissen, 2008; Ofcom, 2008; Pedró, 2007; Vekiri and Chronaki, 2008). Table 3.7 presents profile frequencies by gender.

As the table shows, males dominate the frequent leisure use profiles. Females appear to be a majority in all profiles with moderate or low use for both leisure and educational use, *e.g.* analogue and digi-educational. Differences between boys and girls in frequencies of use of ICTs are also reported in PISA 2003 (OECD, 2006). However, given that the data are self-reported, this may hide a bias that reflects a discourse on gender and ICT, according to which boys use ICT but girls do not necessarily do so. The differences between males and females needs to be further explored as more information is obtained about each profile.

Table 3.7. The percentage of males and females in each profile

Profiles	Analogue	Digi-educational	Digi-casual	Digi-sporadic	Digi-wired	Digi-zapper
OECD female	59.5%	61.8%	51.7%	50.5%	32.6%	32.8%
OECD male	40.1%	38.2%	48.3%	49.5%	67.4%	67.2%

Socio-economic status and student profiles

As discussed in Chapter 2, physical access to computers seems to be universally available in most OECD countries. Still, when access is considered in terms of patterns of use and ability to communicate and to find relevant information, differences are apparent across and within OECD countries. These differences are linked to socio-economic status. This section therefore presents the relation between the different profiles and students' socio-economic background, using the PISA 2006 ESCS index.⁶ Table 3.8 presents the average ESCS score for each of the student profiles.

Table 3.8. **Average index score of socio-economic status (ESCS) in each student's profiles**

Profiles	Analogue	Digi-educational	Digi-casual	Digi-sporadic	Digi-wired	Digi-zapper
OECD	-0.22	-0.40	0.07	-0.09	0.16	-0.15

The table shows that student profiles relate differently to socio-economic status. Digi-educational has an ESCS score that is a 0.40 standard deviation below the average ESCS score (a negative value) for the OECD student population. Digi-wired has an ESCS score that is a 0.16 standard deviation, which is above the average ESCS score (a positive value). Digi-wired and digi-casual have a positive ESCS score, *i.e.* a higher than average score for socio-economic status; the other four profiles (analogue, digi-educational, digi-sporadic and digi-zapper) have negative ESCS scores.⁷

Given these results, a possible interpretation may be that a higher level of ESCS is related to greater leisure use, as higher socio-economic households may have a greater access to computers and other digital devices, such as video games. Conversely, poorer households seem to score comparatively higher on educational uses of ICT, as schools may still represent the main ICT connection for these students. This finding underpins the fact that socio-economic status plays an important role in how students access and use ICTs (Pedró, 2007).

These observations represent a challenge for policy makers, given that they document that differences in frequency and use of ICT are related to socio-economic status (ESCS) and gender. Regarding socio-economic status, a possible consequence might be what has been called the “Matthew effect” (Merton, 1968): those who already possess good cultural capital reinforce it through technology-related practices; those who either do not have access to technology or lack cultural technology will fall behind. In the long run these differences may increase. Therefore, ICT in schools may still play an important role in increasing the digital capacity and familiarity of students from less advantaged households. There is also a gender issue. As shown, different

profiles are dominated by different genders. Digi-wired is the profile with male dominance and a higher than average score of ESCS; analogue and digi-educational are female-dominated and have lower than average ESCS scores. However, digi-casual is a profile with slightly more females than males and a higher than average score of ESCS. The reason for these differences remains unclear and will be further discussed below.

Self-confidence in ICT high-level tasks and student profiles

PISA 2003 provided information on how well students felt they could perform different tasks with a computer, ranging from routine tasks, high-level tasks and Internet tasks (OECD, 2006). PISA 2006 included a set of similar questions, updated owing to changes in technology.⁸ Questions that give information on self-confidence in ICT high-level tasks and Internet tasks and how this relates to the set of profiles are used here. The results are presented in Table 3.9. Positive values on this index indicate high self-confidence.⁹

Table 3.9. Average index of self-confidence for ICT high-level tasks related to student profiles

Profiles	Analogue	Digi-educational	Digi-casual	Digi-sporadic	Digi-wired	Digi-zapper
OECD	-0.67	0.18	-.11	.22	0.24	0.81

The results show that digi-wired, digi-sporadic, digi-zapper and digi-educational have self-confidence for carrying out high-level ICT tasks. Digi-casual and analogue do not. The results show that an increased level of self-confidence in ICT high-level tasks is related to a higher level of leisure use (in all three leisure categories) and a higher level of educational use (in all three educational categories).

One explanation may be that greater use of ICT (and especially educational use) supports students' self-confidence for ICT high-level tasks. These findings may suggest that students find higher levels of educational and of leisure use relevant to their self-confidence in carrying out high-level ICT tasks.

Self-confidence in Internet tasks

Students were also asked about how they perceived their own use of Internet-related activities (OECD, 2007, p. 342). Self-confidence in Internet tasks relates to questions such as chatting on line, searching the Internet for information, downloading files or programmes, attaching a file to an e-mail

message, downloading music and writing e-mails. The results are presented in Table 3.10, and positive values indicate high self-confidence.⁹

The results show that the digi-wired, digi-casual, digi-sporadic and digi-zapper have self-confidence in approaching ICT Internet tasks. Digi-educational and analogue do not.

It seems that an increased level of self-confidence in ICT Internet tasks

Table 3.10. Average index of self-confidence in ICT Internet tasks related to student profiles

Profiles	Analogue	Digi-educational	Digi-casual	Digi-sporadic	Digi-wired	Digi-zapper
OECD	-0.79	-0.65	0.25	0.03	0.52	0.28

is related to greater leisure use (within all three leisure categories) and less educational use (within the frequent leisure and monthly leisure categories). One reason may be an overlap between leisure use and ICT Internet tasks. Consequently, greater leisure use of ICTs may boost students' self-confidence as regards ICT Internet tasks. These findings might indicate that students find leisure use more relevant than educational use for ICT Internet tasks. Other studies report similar findings (Arnseth *et al.*, 2007; Lenhart *et al.*, 2008).

Performance in science and students' profiles

In addition to a more nuanced picture of ICT user profiles, this section aims at shedding some light on the implications of these profiles for educational performance. It presents the scores of the different profiles and suggests a number of correlations between ICT use and educational performance that will be explored in more detail in Chapter 4.

Science performance was central to PISA 2006. This background category was included in the set of profiles and its relation to each profile was explored. PISA's approach was: "[the] science scale was constructed to have a mean score among OECD countries of 500 points, with about two-thirds of students across OECD countries scoring between 400 and 600 points" (OECD, 2007, p. 43). The average grades in science for each profile are presented in Table 3.11.

In PISA 2006 student scores "in science are grouped into six proficiency levels, with level 6 representing the highest scores (and hence the most difficult tasks) and level 1 the lowest scores (and hence the easiest tasks)" (OECD, 2007, p. 44). digi-wired, digi-casual, digi-sporadic and analogue have a level

Table 3.11. **Average index score of performances in science in each student profiles (weighted with BRR)**

Profiles	Analogue	Digi-educational	Digi-casual	Digi-sporadic	Digi-wired	Digi-zapper
OECD	511.093	474.142	521.785	495.559	518.408	457.579

3 (range from 484 to 558) score in science. Digi-sporadic is in the lower part of level 3, with an almost 0.27 standard deviation below digi-casual and an almost 0.23 standard deviation below digi-wired.

The results show that digi-wired and digi-casual achieved the highest results in science and digi-educational and digi-zapper the lowest. The largest differences are found between rare educational users and frequent educational users. For example the average score for digi-wired differs by a 0.60 standard deviation from the average score of digi-educational, and by a 0.44 standard deviation from the average score of digi-zappers. The average score for digi-casuals differs by a 0.63 standard deviation from the average score of digi-zappers and by a 0.47 standard deviation from the average score of digi-educational.

However, there is quite a consistent pattern among students in all leisure categories: higher performance in science is related to lower educational use of computers. One explanation may be that science performance is measured through paper-and-pencil examinations and that educational use of ICT is not a part of how students are assessed. Another explanation might be that the use of ICT for learning purposes in science is still rare, even in countries where the spread of computers and broadband in schools is well documented (Arnseth *et al.*, 2007). Moreover, all these findings must be interpreted with care, as the relation between ICT use profiles and educational performance may hide underlying socio-economic factors that may affect performance results. These aspects are explored in more detail in Chapter 4.

Implications for practice

The set of profiles presented here were developed in order to present a nuanced picture of different types of activities and frequencies of use among 15-year-old students based on data from the PISA and ICT 2006 questionnaire. However, developing profiles presents some obstacles. First, student profiles cannot fully explain all of the nuances and variations in the student sample. It may be difficult to find clear and consistent profiles that are stable over time, since students' use of ICT is changing rapidly. Moreover, there are limitations owing to how the data are collected. A survey (without follow-up) does not provide longitudinal data, but it gives a glimpse of students' patterns of use over a certain period of time. Nevertheless, the development of profiles

represents a fruitful approach towards identifying some categories of typical or non-typical groups of students and their use of ICT.

Profiles might be developed differently by using various methods and theoretical approaches. The approach adopted here relies on a separation between “leisure use” and “educational use” of ICT in order to grasp differences in ICT use among students and on differences in frequencies of use. As mentioned, this mainly artificial separation is a tool for developing the profiles. The profiles are analysed using information on distribution, gender differences, index of socio-cultural status (ESCS), performance in science, self-confidence in carrying out ICT high-level tasks and self-confidence in carrying out ICT Internet tasks. The profiles are considered robust, as they undergone several control tests; these are described in detail in Annex B.

The six profiles help give a better picture of the new millennium learners and their attitudes towards and activities related to ICT; they are briefly summarised in Table 3.12. As has been shown, the picture is quite nuanced. The focus on six profiles has made it possible to move from the dichotomy of the “male gamer” and the “female communicator” to a more complex picture of a range of different user profiles with varying relations to gender, to ESCS and to academic performance in science. These findings may have implications for future policy making on education and ICT as well as for research. It is necessary to look more closely at how students use ICT for educational purposes.

The results indicate certain differences between males and females in their use of ICTs. First, it seems that males more often report frequent leisure use of technology. They tend to dominate the “almost every day” or “once or twice a week” reported usage. As noted, this is in line with previous findings. Females’ use of technology appears to be more oriented towards educational purposes. Moreover, females dominate “the rare leisure” category, and there are slightly more females than males among digi-sporadics.

The results show that the level of socio-economic background (ESCS) increases as levels of leisure use increase, and levels of ESCS decrease as levels of educational use decrease. It is slightly surprising that digi-wired, digi-casual and analogue score a higher level of ESCS than digi-zapper. The observation that ESCS is positively related to leisure use and not to educational use would benefit from further study. Moreover, as mentioned, this may be related to an emerging digital divide in terms of attitudes and patterns of ICT use, and this too would benefit from further research.

The findings do not show any consistent patterns in terms of leisure use. However, the results show that higher levels of performance in science are related to lower levels of educational use of computers. This is rather surprising, but may be due to the lack of ICT-based assessments in schools. Science

education and examinations are rather traditional, and educational software and educational use of programmes do not seem common in science (according to students' experience in 2006). However, as noted, this may be due to a lack of use of ICT for learning purposes, even in countries well equipped with computers and broadband (Arnseth *et al.*, 2007).

As for the level of self-confidence in ICT high-level tasks and in ICT Internet tasks, both leisure use and educational use are important for developing self-confidence in carrying out high-level ICT tasks, although that leisure use is more important than educational use. Results also show that

Table 3.12. **Summarising findings about six important students' profiles**

	Rare educational	Monthly educational	Frequent educational
Frequent leisure	Digi-wired (19.7%) • Male-dominated • Positive ESCS • Medium level 3 score in science • Positive self-confidence Internet tasks • Positive self-confidence high-level tasks		Digi-zapper (6.9%) • Male-dominated • Negative ESCS • Level 2 score in science • Positive self-confidence Internet tasks • Positive self-confidence high-level tasks
Monthly leisure	Digi-casual (18.6%) • Slightly more females than males • Positive ESCS • Medium level 3 score in science • Positive self-confidence Internet tasks • Negative self-confidence high-level tasks	Digi-sporadic (3.9%) • Slightly more females than males • Negative ESCS • Low level 3 score in science • Moderate self-confidence Internet tasks • Positive self-confidence high-level tasks	
Rare leisure	Analogue (37.7%) • Female-dominated • Negative ESCS • Medium level 3 score in science • Negative self-confidence Internet tasks • Negative self-confidence high-level tasks		Digi-educational (1.5%) • Female-dominated • Negative ESCS • Level 2 score in science • Negative self-confidence Internet tasks • Positive self-confidence high-level tasks

leisure use is more relevant than educational use for self-confidence in ICT Internet tasks.

In sum, the set of profiles shows that students' uses of computers relate to their socio-economic status (ESCS) and gender. Differences in uses and preferences appear linked to academic performance in science. While both girls and boys use computers for leisure and educational purposes, the analogue profile is female-dominated and the digi-wired profile is male-dominated in most OECD countries. The digi-wired profile points to higher than average ESCS scores, higher than average grades in science and positive self-confidence in ICT high-level tasks and Internet tasks. Both analogue and digi-educational are female-dominated profiles, with lower than average ESCS score and self-confidence in ICT Internet tasks. Analogues have slightly weaker performance in science than digi-wired and below average self-confidence in ICT Internet tasks. Digi-educational perform below average in science, but their self-confidence in ICT high-level tasks is above average. However, the picture is complex, as digi-casuals are slightly female-dominated, but have a positive socio-economic status, good performance in science and confidence in high-level ICT tasks. Nonetheless, these differences indicate that the digi-wired appear better prepared for future studies and for participation in a digital society.

The findings suggest that a digital divide still exists between girls and boys with regard to their leisure use of computers. It would appear to be important to help both female and male analogues increase their use of computers. Moreover, students who report rare or no use of computers lag behind students with the other profiles. This may indicate a digital divide that can be related to frequency of leisure use of ICT and thus the challenges to schools to avoid a new digital divide that is due to the situation of parents and/or gender background variables. However, all students should not be encouraged to become digi-zappers.

It would have been interesting to have longitudinal data in order to follow the students over the years and throughout various ICT-related activities. Future research would benefit from exploring how students are using ICT in their learning process for educational purposes and the implications of ICT use for practice and performance. It would also be important to explore the relation between ICT use and self-confidence in ICT (high-level tasks and Internet). There are two relevant research questions: How can increased educational or leisure use have a positive impact on self-confidence relating to ICT? Do students with high levels of self-confidence benefit from their self-confidence as they move on (e.g. into high school)?

ICT use and attitudes to science

Is there a clear link between students' intensity and type of use of information technology and their attitude towards science? One might expect some degree of association as students using ICT might have certain personal characteristics, such as curiosity, that could trigger an interest in science. Following the general approach towards a profile of student engagement in science (OECD, 2007, Chapter 3), this section looks at various indices of attitudes towards science and how they change with the frequency of computer use at home and at school. The role potentially played by some specific uses of ICT relating to the use of the Internet in students' attitudes towards science is also examined.

In order to place this relation in a more holistic framework, a number of variables that may affect the sign and strength of the relations, and therefore need to be controlled for, are taken into account. These variables are gender and socio-economic status and an immigrant background.

The effect of gender and socio-economic status on the use of ICT is explored in previous sections and may also play an important role in students' attitudes towards science. For gender, previous research on ICT, gender and education has unveiled some differences (Faulkner, 2007; Lenhart *et al.*, 2007; Meelissen, 2008; OECD, 2008; Pedró, 2007; Tømte, 2008). Gender differences – in terms of attitudes, time spent, frequency and pattern of ICT use – have often been offered as possible explanations for why girls are less inclined than boys to choose education in computing or become ICT professionals (Beavis, 2007; Meelissen, 2008; Montagnier and Van Welsum, 2007). Moreover, environmental and social factors which have been used to explain gender-related views of ICT may also be relevant. For example, gender differences in attitudes may be linked to cultural stereotypes (Vekiri and Chronaki, 2008). Gender characteristics may thus provide an opportunity to see how ICT use affects male and female attitudes to science in different ways. It is also interesting to learn about the level of use of ICT among students from households which speak a language different from that of instruction and to see whether this has repercussions on their attitudes towards science.

Methodology

For the sake of simplicity, frequency of use is split into two categories: “almost every day” and “other”. The latter includes “a few times each week”, “between once a week and once a month”, “less than once a month” and “never”.

Attitude towards science is captured through a series of nine indices, calculated on the basis of nine sets of questions (OECD, 2007, Chapter 3). Three

of the nine indices are used to explain attitudes towards science. They are chosen because they are distinct and reflect a gradation in terms of attitudes towards science from broad and general to personal interest and involvement. These three indices are: general value of science (GVS), general interest in science (GIS) and science-related activities (SRA)

For each of these indices, the variation in the value of the index due to an increase in the frequency of computer use is analysed. Variation at the country level is broken down according to the three characteristics of the students mentioned above: whether they belong to the highest or lowest quarter of the index of economic, social and cultural status (ESCS), their gender, and immigrant background.

Results

This section presents the main findings on how the indices vary according to the use of computers at home, use of computers in school, and different Internet-related computer uses.

Use of computer at home

Index 1: general value of science (GVS)

For the ESCS index at country level, higher frequency of computer use at home increases the GVS index in all countries but Korea. However, among students from more advantaged socio-economic backgrounds, the effect is positive in four countries out of five, but it is negative in Finland, Korea, Norway and Turkey, and has almost no effect in the Slovak Republic. Among students from less advantaged socio-economic backgrounds, the effect is also positive in a large majority of countries, and it is negative in Germany, Greece, the Slovak Republic, Sweden and Turkey.

As Figure 3.6. shows, the frequency effect (higher frequency of computer use) is positive among men students in all countries except Korea, where it has no effect. Among female students, the frequency effect is also positive in all but six countries.

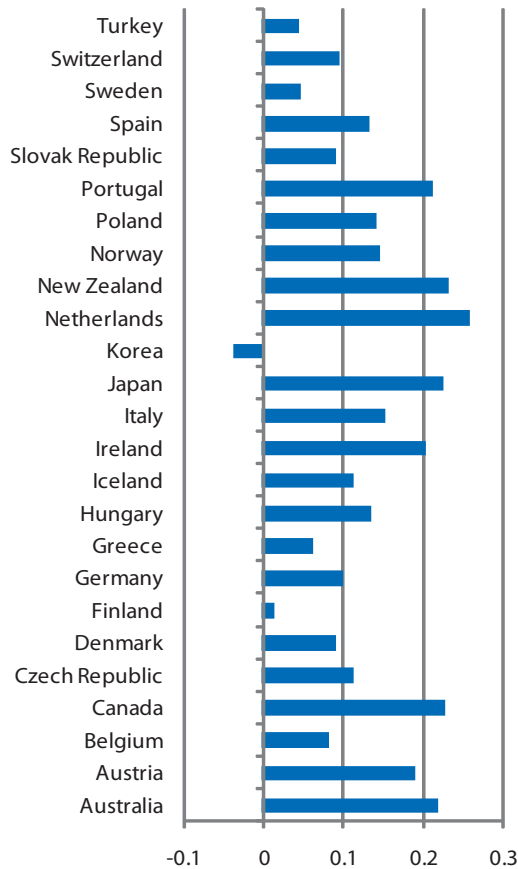
Among students with an immigrant background, frequency of computer use has a negative effect in only five countries. For students that do not have an immigrant background, higher frequency of computer use has a negative effect only in Korea.

Index 5: general interest in science (GIS)

In a majority of OECD countries, the higher the frequency of computer use, the higher the GIS index. The reverse is found in nine countries, but the effect is only very slightly negative in seven of these.

As in the case of the general value of science, students from higher socio-economic backgrounds in OECD countries tend to have a higher GIS index (see also OECD 2007, Chapter 3), as Table 3.13 shows. Higher frequency has a positive effect among students from less advantaged socio-economic backgrounds in 13 countries and a negative effect in 11. By contrast, among students from more advantaged socio-economic backgrounds, the effect is predominantly negative except in five countries. In Sweden and Korea,

Figure 3.6. Use of computer at home and general value of science



StatLink  <http://dx.doi.org/10.1787/812163867760>

higher frequency of computer use gives a lower level of GIS for students from both more and less advantaged socio-economic backgrounds, as well as overall.

At the country level, it has been emphasised that the reported level of GIS seems to be similar for male and females in most reporting countries (OECD 2007, Chapter 3). As for the previous index, the frequency of computer use has a positive effect on the GIS for male students in most OECD countries but in only ten countries for female students.

Table 3.13. Use of computer at home and general interest in science

	Q4	Q1	ALL
Australia	-0.012	0.047	0.083
Austria	-0.141	0.055	0.060
Belgium	-0.151	0.008	-0.006
Canada	-0.169	0.036	0.053
Czech Republic	-0.018	0.062	0.056
Denmark	0.011	-0.086	0.006
Finland	-0.190	-0.043	-0.032
France	..	..	..
Germany	-0.070	0.015	-0.017
Greece	-0.020	0.140	0.125
Hungary	-0.100	0.016	0.001
Iceland	-0.093	-0.016	0.063
Ireland	0.049	0.147	0.161
Italy	-0.014	0.054	0.067
Japan	0.079	0.112	0.155
Korea	-0.162	-0.171	-0.215
Luxembourg	..	..	..
Mexico	..	..	..
Netherlands	-0.174	-0.019	-0.034
New Zealand	-0.020	-0.046	0.037
Norway	-0.050	0.030	0.064
Poland	-0.058	-0.047	-0.012
Portugal	0.008	0.096	0.094
Slovak Republic	-0.036	-0.047	0.028
Spain	0.047	-0.083	0.011

Table 3.13. Use of computer at home and general interest in science
(continued)

	Q4	Q1	ALL
Sweden	-0.249	-0.130	-0.131
Switzerland	-0.101	0.006	-0.009
Turkey	-0.071	-0.134	-0.005
United Kingdom	..	..	..
United States	..	..	..
OECD average	-0.068	0.000	0.024

StatLink  <http://dx.doi.org/10.1787/812471465566>

Q4 refers to the students who belong to the highest quartile of the Economic, Social and Cultural Status (ESCS) index and Q1 to those who belong to the lowest quartile. In the case of Australia, the difference between high frequency use of a computer at home (almost every day) and a low frequency (other) mirrors a decrease of the value of the General Interest in Science (GIS) index for students of Q4 (-0.012). The same difference mirrors, by contrast, an increase of the GIS index for students who belong to Q1 (0.047)³, and similarly an increase for all students together (0.083).

The effects of frequency of computer use for students with an immigrant background vary among countries. In Austria, Iceland, Japan, Norway and Sweden, it is positive. In Austria, Iceland and Japan, the effect is positive for students without an immigrant background. Finally, in Australia, Germany, Ireland, the Netherlands, New Zealand, Poland and the Slovak Republic, the situation is relatively symmetrical: higher frequency of computer use has a negative effect on students with an immigrant background, and a positive one on the other students.

Only a minority of students reported that they engaged regularly in science-related activities. It has been observed that student's socio-economic background is strongly associated with engagement in science-related activities (OECD 2007, Chapter 3). Overall, higher frequency of computer use at home is linked to increased engagement in science-related activities in almost all OECD countries. This positive effect is observed for students from less advantaged socio-economic backgrounds in almost two-thirds of countries. Among students from more advantaged socio-economic backgrounds, the effect is balanced between a negative and a positive effect in an equal number of countries.

Stronger engagement in science-related activities linked to higher frequency of computer use at home is observed for male students in a much larger number of countries than for female students (Table 3.14).

Among students with an immigrant background, the effect is relatively balanced between countries where it is negative and countries where it is

positive. For native-born students, the effect is positive in a large majority of countries. Overall, the effect appears positive in more countries for native-born students than for students with an immigrant background.

Table 3.14. Use of computer at home and science-related activities

	Q4	Q1	(Q4-Q1)	ALL
Australia	-0.263	-0.095	-0.168	0.039
Austria	-0.184	-0.040	-0.144	0.048
Belgium	0.002	0.001	0.001	-0.053
Canada	0.040	0.048	-0.008	0.015
Czech Republic	-0.123	0.010	-0.133	0.005
Denmark	..	..	..	0.037
Finland	0.074	0.002	0.072	-0.041
France	0.132	0.217	-0.085	..
Germany	-0.061	0.042	-0.103	0.038
Greece	0.066	0.037	0.029	0.208
Hungary	0.182	0.146	0.036	0.027
Iceland	0.105	0.163	-0.058	0.108
Ireland	0.250	0.131	0.119	0.267
Italy	-0.117	-0.183	0.066	0.197
Japan	..	..	..	0.274
Korea	..	..	..	-0.190
Luxembourg	-0.079	0.072	-0.151	..
Mexico	0.128	-0.008	0.136	..
Netherlands	-0.142	-0.028	-0.114	0.027
New Zealand	-0.083	0.033	-0.116	0.113
Norway	0.040	0.010	0.030	0.018
Poland	-0.057	0.057	-0.114	0.027
Portugal	0.081	-0.026	0.107	0.096
Slovak Republic	-0.004	-0.092	0.088	0.013
Spain	-0.028	-0.043	0.015	0.040
Sweden	0.039	0.088	-0.049	0.026
Switzerland	..	..	..	-0.021
Turkey	..	..	..	0.107
United Kingdom	-0.147	0.567	-0.714	..
United States	..	..	..	..
OECD average	-0.009	0.013	-0.022	0.057

StatLink  <http://dx.doi.org/10.1787/812504078375>

Q4 refers to the students who belong to the highest quartile of the Economic, Social and Cultural Status (ESCS) index and Q1 to those who belong to the lowest quartile.

Index 9: science-related activities (SRA)

As for computer use at home, the variation of the value of the index due to an increase in the frequency of computer use at school is analysed.

Use of computer at school

Index 1: general value of science (GVS)

An increase in the frequency of computer use at school tends to increase the GVS index in a majority of countries; in about one-third, the effect is negative (Table 3.15). For use at home this was only the case for Korea. Among students from less advantaged socio-economic backgrounds, the effect is positive in about two-thirds of the countries. The balance between the number of countries in which the effect is negative and those in which the effect is positive is more or less the same for students from more advantaged socio-economic backgrounds.

There are several noteworthy findings:

- In Finland, Ireland, Spain and Switzerland, increased frequency has a positive effect on students from more advantaged socio-economic backgrounds and a negative effect on those from less advantaged backgrounds. In these countries, regular use of a computer within the school system seems to amplify the divergence between students from more and less advantaged socio-economic backgrounds as GVS becomes even more negative for the latter as the frequency of computer use at school increases.
- In Canada, the Czech Republic, New Zealand, Poland and the Slovak Republic, the opposite situation is found. More frequent use of a computer at school tends to raise the GVS index among students from less advantaged socio-economic backgrounds, while decreasing it among students from more advantaged socio-economic backgrounds.
- In Australia, Austria, Japan and Korea, increased frequency of computer use at school increased the GVS among students both from more and less advantaged socio-economic backgrounds, but relatively more for the latter.
- In Denmark, Germany, Portugal and Sweden, the situation is similar, but the increase is relatively more important among students from a more advantaged socio-economic background.

Socio-economic background does not have an effect on students' GVS when they use a computer at school, in contrast to their use of a computer at home.

Table 3.15. Use of computer at school and general value of science

	Q4	Q1	ALL
Australia	0.093	0.130	0.134
Austria	0.021	0.034	-0.008
Belgium	-0.010	-0.134	-0.106
Canada	-0.051	0.054	0.036
Czech Republic	-0.044	0.155	0.119
Denmark	0.039	0.012	0.019
Finland	0.374	-0.266	-0.041
France			
Germany	0.593	0.261	0.140
Greece	0.066	-0.097	-0.055
Hungary	0.043	-0.012	0.034
Iceland	0.196	-0.241	0.063
Ireland	0.111	-0.261	-0.034
Italy	-0.271	-0.109	-0.242
Japan	0.082	0.297	-0.028
Korea	0.033	0.150	0.116
Luxembourg			
Mexico			
Netherlands	0.036	-0.029	0.033
New Zealand	-0.027	0.040	-0.006
Norway	0.035	-0.072	0.043
Poland	-0.143	0.115	-0.030
Portugal	0.242	0.110	0.068
Slovak Republic	-0.071	0.064	-0.010
Spain	0.154	-0.099	0.042
Sweden	0.170	0.039	0.186
Switzerland	0.242	-0.364	0.086
Turkey	0.377	0.000	0.009
United Kingdom			
United States			
OECD average	0.092	-0.009	0.023

StatLink  <http://dx.doi.org/10.1787/812528785105>

Q4 refers to the students who belong to the highest quartile of the Economic, Social and Cultural Status (ESCS) index and Q1 to those who belong to the lowest quartile.

Unlike the use of a computer at home, increased frequency of use of a computer at school does not have an overall positive impact in all countries. There is a balance between countries in which the effect is positive and those in which it is negative. For the use of a computer at home, the effect is almost systematically positive for male students, but at school, it is positive only in Canada, Japan, Korea, Norway, Sweden and Switzerland. In about one-third of countries, frequent use of a computer in the school system seems to have a positive impact for the GVS index of female students. Higher frequency of computer use affects the GVS index positively or negatively an equal number of countries.

Index 5: general interest in science (GIS)

As for computer use at home, increased frequency of computer use at school generally has a positive effect on the GIS at the country level (Table 3.16). It has a positive effect relatively more among students from more advantaged socio-economic backgrounds. The effect among students from less advantaged socio-economic backgrounds is positive in 12 countries and negative in 13; among students from more advantaged socio-economic backgrounds, it is positive in 15 and negative in 10. Higher frequency of computer use at school, as opposed to home, seems to influence the GIS index of students from more advantaged socio-economic backgrounds more positively. For home use, the positive effect on the GIS index was greater for students from less advantaged socio-economic backgrounds.

With respect to gender and immigrant background, the effect of an increase in the frequency of computer use at school seems to be equally divided between countries where it is negative and where it is positive.

Index 9: Science-related activities (SRA)

Higher frequency of computer use at school, as for computer use at home, has an overall positive impact on the SRA index in most countries (Table 3.17). This is the case in a slightly greater number of countries for students from less advantaged socio-economic backgrounds than for students from more advantaged socio-economic backgrounds.

Overall, more frequent computer use at school has a positive effect among male students in all countries but two and among female students in all countries but six.

Higher frequency has a positive effect in a majority of countries both for students with an immigration background and for those without. However, it seems to have a negative effect for students with an immigration background in a greater number of countries.

Table 3.16. Use of computer at school and general interest in science

	Q4	Q1	ALL
Australia	-0.012	-0.011	0.037
Austria	0.095	0.124	0.059
Belgium	-0.287	-0.146	-0.298
Canada	-0.012	0.027	0.038
Czech Republic	-0.145	0.173	0.015
Denmark	-0.100	-0.103	-0.066
Finland	0.245	0.048	0.004
France	0.000	0.000	0.000
Germany	-0.029	0.244	-0.021
Greece	0.027	-0.130	0.009
Hungary	0.217	0.139	0.112
Iceland	0.002	-0.101	0.013
Ireland	0.001	-0.253	-0.015
Italy	-0.204	-0.207	-0.196
Japan	-0.032	0.362	0.070
Korea	0.142	0.014	0.051
Luxembourg	0.000	0.000	0.000
Mexico	0.000	0.000	0.000
Netherlands	-0.061	-0.033	-0.039
New Zealand	-0.116	0.108	0.022
Norway	0.048	-0.056	0.036
Poland	0.104	0.020	0.162
Portugal	0.155	0.073	0.015
Slovak Republic	0.041	0.132	0.034
Spain	0.189	-0.010	0.004
Sweden	0.155	-0.159	0.125
Switzerland	0.153	-0.146	0.042
Turkey	0.299	-0.196	0.079
United Kingdom	0.000	0.000	0.000
United States	0.000	0.000	0.000
OECD average	0.035	-0.003	0.012

StatLink  <http://dx.doi.org/10.1787/812542666830>

Q4 refers to the students who belong to the highest quartile of the Economic, Social and Cultural Status (ESCS) index and Q1 to those who belong to the lowest quartile.

Table 3.17. Use of Internet at school and science-related activities

	Q4	Q1	ALL
Australia	0.097	0.202	0.154
Austria	-0.022	0.030	-0.026
Belgium	-0.082	0.014	-0.179
Canada	0.135	0.017	0.124
Czech Republic	-0.018	0.162	0.091
Denmark	-0.111	0.047	-0.004
Finland	0.527	0.125	0.158
France	0.000	0.000	0.000
Germany	-0.006	0.340	0.125
Greece	0.196	0.095	0.142
Hungary	0.139	0.231	0.105
Iceland	0.203	0.168	0.148
Ireland	0.056	-0.025	0.060
Italy	0.077	-0.091	-0.064
Japan	0.000	0.269	0.069
Korea	0.032	0.078	0.061
Luxembourg	0.000	0.000	0.000
Mexico	0.000	0.000	0.000
Netherlands	0.097	0.128	0.104
New Zealand	-0.036	0.118	0.047
Norway	0.267	0.135	0.178
Poland	0.374	0.134	0.292
Portugal	0.365	0.052	0.067
Slovak Republic	0.056	0.255	0.158
Spain	0.121	0.118	0.115
Sweden	0.134	0.139	0.227
Switzerland	0.341	0.211	0.345
Turkey	0.515	-0.265	0.039
United Kingdom	0.000	0.000	0.000
United States	0.000	0.000	0.000
OECD average	0.138	0.107	0.101

StatLink  <http://dx.doi.org/10.1787/812634652208>

Q4 refers to the students who belong to the highest quartile of the Economic, Social and Cultural Status (ESCS) index and Q1 to those who belong to the lowest quartile.

Selected Internet activities

Four Internet activities were selected. One, rather general, was “browse the Internet”. The second, participative in nature, was “collaborate on the Internet”. The third, leisure-oriented, is “play games”. The last, work- and ICT-skills-oriented, was “write programmes”. As for use of a computer at home and at school, for each of those activities, frequency was broken down between high (almost every day) and low (a few times each week, between once a week and once a month, less than once a month, and never). The effect of the activity on indices of attitude towards science is measured by looking at the variation of the index between high and low frequency. For the activities, this variation was observed for the index of economic, social and cultural status (ESCS) and gender. Immigration background was omitted.

Index 1: general value of science (GVS)

Overall, for the four selected Internet activities, higher frequency of use has a slight negative effect on the GVS index in about two-thirds of countries. There is a slight positive effect in the remaining third. However, the two groups are not the same for each of the four activities.

Playing games is the only activity for which a negative effect appears in a larger number of countries for students from less advantaged backgrounds than for students from more advantaged backgrounds. Symmetrically, this is also the only of the four activities for which a positive effect is found in more countries for students from more advantaged backgrounds than for students from less advantaged backgrounds.

The situation therefore differs from the use of a computer at home, where higher frequency has a positive effect for students from both less and more advantaged backgrounds: higher frequency of Internet activities seems to have an overall negative effect on the index.

High frequency of browsing the Internet (Table 3.18) and writing programmes has a negative effect on the GVS for female students in a significantly larger number of countries than for male students. For male students, the effect is positive in a significantly larger number of countries than for female students.

For collaboration on Internet and playing games, the negative and positive effects seem to be balanced between similar numbers of countries.

Index 5: general interest in science (GIS)

Overall, the frequency of computer use for the selected activities has a negative effect on the GIS index for a majority of OECD countries. The negative effect seems to be stronger for female than for male students and

Table 3.18. **Browsing the Internet and general value of science**

	Q4	Q1	ALL
Australia	-0.006	0.008	-0.005
Austria	0.064	-0.017	0.035
Belgium	-0.016	-0.079	-0.016
Canada	-0.045	-0.075	0.004
Czech Republic	-0.127	0.017	0.001
Denmark	-0.020	-0.070	0.003
Finland	0.074	-0.106	-0.031
France	0.003	-0.090	-0.006
Germany	0.125	0.013	0.027
Greece	-0.006	0.023	-0.031
Hungary	-0.181	-0.030	-0.051
Iceland	-0.213	0.181	-0.053
Ireland	0.025	0.080	0.002
Italy	-0.040	0.034	0.018
Japan	-0.068	-0.011	-0.016
Korea	0.019	-0.013	0.045
Luxembourg	-0.060	-0.088	-0.036
Mexico	-0.004	0.000	-0.041
Netherlands	-0.036	-0.045	-0.036
New Zealand	-0.040	-0.190	-0.071
Norway	0.043	-0.086	0.026
Poland	-0.026	0.019	-0.013
Portugal	-0.038	-0.042	-0.015
Slovak Republic	0.023	-0.066	0.006
Spain	-0.061	0.075	-0.015
Sweden	0.012	0.184	0.036
Switzerland	0.063	0.015	0.012
Turkey	-0.182	-0.028	-0.056
United Kingdom	-0.102	0.126	-0.001
United States	0.017	-0.085	0.030
Average OECD	-0.027	-0.012	-0.008

StatLink  <http://dx.doi.org/10.1787/812653128707>

Q4 refers to the students who belong to the highest quartile of the Economic, Social and Cultural Status (ESCS) index and Q1 to those who belong to the lowest quartile.

stronger for students from more advantaged backgrounds than for those from less advantaged backgrounds.

The activity “browse the Internet” shows the biggest gap between the positive and negative effects of frequent use (Table 3.19). There are 19 countries in which the effect is negative and only 11 countries in which it is positive. The negative effect is more important for female than for male students.

“Playing games” shows a negative effect for 16 out of 30 countries. The effect is balanced between female and male students and is slightly more negative for students from advantaged backgrounds. The most striking effect concerns students from less advantaged backgrounds, with a negative effect on the GIS index in 20 countries.

Collaborating on the Internet and writing programmes, which are strongly work-oriented activities, do not show any positive effect, as might be expected. The overall effect is balanced for “collaborating on the Internet”, with more countries showing negative effects in the female student population and in students from a advantaged background. The “writing programme” activity has the most balanced pattern, especially in terms of the socio-economic background of students, as the positive and negative effects are found in 15 countries.

Index 9: Science-related activities (SRA)

For each of the four selected activities, higher frequency of computer use has a negative effect on the SRA index in a strong majority of countries, though the effect is smaller for “playing games”. For playing games, higher frequency has a negative effect for students from less advantaged backgrounds in a larger number of countries than for students from more advantaged backgrounds.

The reverse is true for writing programmes: higher frequency has a negative effect on the SRA index for students from less advantaged backgrounds in a smaller number of countries than for students from more advantaged backgrounds.

For female and male students, the effect of higher frequency of playing games does not seem clear-cut. However, higher frequency of collaboration on the Internet and of writing programmes has a negative effect on the SRA index in a much larger number of countries for male students than for female students, and a positive effect in a much smaller number of countries for male students than for female students. Overall, for both activities, the effect seems more positive for female than for male students. Higher frequency of browsing the Internet seems to have a slightly higher negative effect on female students than on male students (Table 3.20).

Table 3.19. **Browsing the Internet and general interest in science**

	Q4	Q1	ALL
Australia	0.020	-0.054	-0.002
Austria	-0.008	0.086	0.015
Belgium	-0.099	-0.047	-0.031
Canada	0.004	-0.088	-0.011
Czech Republic	0.024	0.085	0.026
Denmark	0.041	0.070	0.020
Finland	-0.003	-0.046	-0.038
France	0.007	0.013	0.009
Germany	-0.071	-0.050	-0.023
Greece	-0.074	-0.023	-0.012
Hungary	-0.022	-0.002	-0.026
Iceland	-0.318	0.232	-0.073
Ireland	0.005	0.053	0.023
Italy	-0.069	-0.055	-0.047
Japan	-0.132	-0.010	-0.035
Korea	-0.073	-0.004	0.034
Luxembourg	0.034	0.030	0.040
Mexico	-0.051	0.091	0.026
Netherlands	0.041	-0.154	-0.059
New Zealand	-0.039	-0.181	-0.044
Norway	0.160	0.002	0.063
Poland	-0.064	-0.017	-0.092
Portugal	-0.051	-0.079	-0.029
Slovak Republic	0.071	0.007	-0.003
Spain	0.036	-0.025	-0.028
Sweden	-0.018	0.139	-0.024
Switzerland	-0.008	-0.064	-0.027
Turkey	-0.041	-0.100	-0.005
United Kingdom	-0.049	0.065	0.018
United States	-0.158	0.263	0.193
Average OECD	-0.030	0.005	-0.005

StatLink  <http://dx.doi.org/10.1787/812682082167>

Q4 refers to the students who belong to the highest quartile of the Economic, Social and Cultural Status (ESCS) index and Q1 to those who belong to the lowest quartile.

Table 3.20. **Browsing the Internet and science-related activities**

	Q4	Q1	ALL
Australia	0.001	-0.074	-0.050
Austria	0.038	-0.044	-0.014
Belgium	-0.096	-0.075	-0.033
Canada	0.022	0.006	-0.002
Czech Republic	-0.043	0.149	-0.002
Denmark	0.102	0.026	0.055
Finland	0.120	-0.073	0.010
France	0.050	0.129	0.052
Germany	0.014	-0.031	0.033
Greece	-0.097	0.068	-0.041
Hungary	0.032	-0.064	0.023
Iceland	-0.168	0.169	0.034
Ireland	0.012	0.155	0.015
Italy	-0.022	0.027	-0.014
Japan	-0.043	-0.010	-0.021
Korea	-0.145	0.037	-0.012
Luxembourg	0.027	0.029	0.060
Mexico	-0.066	0.069	0.020
Netherlands	-0.008	-0.129	-0.047
New Zealand	0.136	-0.148	-0.005
Norway	0.111	-0.103	-0.006
Poland	-0.095	-0.009	-0.081
Portugal	-0.089	-0.091	-0.038
Slovak Republic	0.045	-0.079	0.014
Spain	-0.087	-0.093	-0.049
Sweden	-0.044	0.063	-0.047
Switzerland	0.101	-0.069	0.012
Turkey	-0.019	-0.143	-0.055
United Kingdom	-0.003	-0.053	-0.025
United States	-0.053	-0.042	0.086
Average OECD	-0.009	-0.013	-0.004

StatLink  <http://dx.doi.org/10.1787/812684100055>

Q4 refers to the students who belong to the highest quartile of the Economic, Social and Cultural Status (ESCS) index and Q1 to those who belong to the lowest quartile.

Summing up

There seems to be no clear strong positive link between the intensity and the way students use ICT and their attitude towards science, except for the use of a computer at home and to a lesser extent at school for science-related activities.

Increased **frequency of use of a computer at home** has an increasing, *i.e.* positive, effect on two of the indices of the attitude towards science, GVS and SRA. For GIS the effect is also positive but in a smaller number of countries.

For all the indices, the number of countries in which the effect is positive for students from a less advantaged socio-economic background is always greater or equal to the number of countries where the effect is positive for students from a more advantaged socio-economic background.

For all the indices the effect is positive in a large majority of countries for male students and in a much smaller number of countries for female students. This is the only slight sign of a possible gender difference regarding the effect of ICT use on attitudes towards science at the OECD level.

Finally, there is no clear trend on the effect of an immigrant background across the indices.

Increased **frequency of computer use at school** does not have the same impact on the various indices. Though the impact is positive in a majority of countries, especially for the SRA index, it is more nuanced in terms of student's gender or socio-economic background.

The effect of increased frequency of computer use, at home or at school, is systematically positive (for all indices) only in Australia, Canada, Portugal and Spain. However, in all of these countries, the effect of increased frequency in the four selected Internet activities is negative on a majority of indices.

None of the four **Internet activities** selected (browsing, collaborating, playing games and writing) significantly affects the science attitude indices when frequency of use increases. In a slight majority of countries, the effect of an increase is null or negative. For all the activities except playing games, the effect is negative in a greater number of countries for students from a low socio-economic background than for those from a high socio-economic background.

If increased frequency of computer use seems to have an overwhelmingly positive effect on attitudes towards science when used at home, the effect is much less significant for computers used at school. Increased frequency of use of selected Internet activities has no clear impact on attitudes towards science.

Conclusions and policy recommendations

Examination of the frequency and patterns of ICT use provides a picture of how students are taking advantage of the opportunities made available by ICT. Once they have access, types of ICT use depend on variables related to students' cognitive, cultural and socio-demographic characteristics. This chapter has given special attention to students' gender and socio-economic status.

The analysis of PISA 2006 data shows that in most OECD countries there are more frequent users of ICT at home than at school. Schools in these countries do not play as great a role as places of access to the digital world as they do in many developing countries. Nevertheless, this does not mean that schools should not play a role in preparing new generations to use ICT for the knowledge-based society. In a context of intensive ICT use at home, particularly for leisure purposes, schools have the opportunity to become places where the full educational potential of digital tools is achieved. For this, governments should promote the study, follow-up and scale-up of good practices of ICT use that affect learning.

The fact that home use tends to be much more intensive than school use also suggests that students without home access cannot carry out many of the activities that the majority of youngsters in OECD countries practice in their daily lives as participants in the digital culture. In addition, 15-year-old students from less advantaged socio-economic backgrounds are less likely to use ICT for leisure purposes than their counterparts from more advantaged backgrounds. Although the use of ICT for programming and software is more likely related to schoolwork, some Internet and entertainment uses may have important learning effects, especially in terms of the skills and competencies that are increasingly relevant in the knowledge society. There is still much to learn regarding these skills and competencies and how the use of technology enhances them. It is therefore important that governments bring experts together to develop adequate instruments to measure them and design the policies needed to support students that are lagging behind.

In terms of gender, although PISA data show that the gender gap has decreased in OECD countries for some activities since PISA 2003, female and male students continue to show important differences in their patterns of ICT use. Males use ICT for a wider range of activities and are more likely to use ICT for leisure purposes than females. Females use ICT more for communication and for schoolwork. Furthermore, females declare themselves less confident than males when using ICT. Finally, although gender differences are relatively small for ICT activities for educational use, they are more significant for higher-level tasks. Although findings related to gender differences should be a matter of concern and call for further study, they should be interpreted with caution. Recent research has shown that youngsters' self-reports in

OECD countries may be influenced by dominant discourse and stereotypes related to gender and ICT and may not accurately reflect their actual practices. In addition, the profiles analysis revealed a far more complex picture by looking closely at different uses and approaches to ICT based on different combinations of student characteristics, relating not only to gender and socio-economic status but also to individual variables such as self-confidence in doing ICT activities and performance on the PISA science test. More studies of this type should be carried out at national as well as international level.

It is important to learn more about the effects of gender and socio-economic differences and the emergence of different profiles of ICT 15-year-old users. It is not yet clear whether these differences simply reflect different ways of approaching the digital culture or if they have consequences for learning the skills and competences needed for the knowledge society. More research on these issues would help to orient policy decisions in order to prevent what has been called the second-level digital divide, that is, differences in the capacity to take full advantage of ICT in the context of the knowledge society.

Finally, PISA data do not provide enough information to learn whether home use and school use influence each other. They do show that one type is not gaining on the other in OECD countries, as on average students' frequent use increased similarly for both since PISA 2003. It is important to learn more about this relation and to design school policies that develop a closer connection between students' ICT uses at home and at school. This would make it possible to link school and home learning more closely, for example by developing online learning resources that students could access and use from home. Also, schools could build a bridge between students' in-school and out-of-school culture, for example by including some out-of-school digital activities in school lessons or after-school activities. Finally, schools might communicate more regularly with parents and engage them more actively in their children's education, for example by communicating with them via the Internet. It is important to address at the same time the digital divide issues that might be raised by these initiatives, such as providing disadvantaged students with access to ICT out of school and following parents' ability to support home use of ICT for school-related activities.

Key findings

- The majority of 15-year-old students use their computers more frequently at home than at school. In most OECD countries more than 80% use computers at home several times a week; only in Hungary do a slight majority of students use them more frequently at schools. Since PISA 2003, frequency of use has increased in all locations. Frequent use in the home and in school increased by a similar percentage.

- Students use computers for a wide range of functions, mostly relating to use of Internet and entertainment. Certain uses, such as Internet research, have educational potential, but as in PISA 2003 students made less frequent use of specific educational software than of any other use.
- The majority of students are confident about their Internet abilities. While fewer believe they can perform high-level tasks unaided, most think they could do so with some help.
- Gender and socio-economic status are related to different uses of, and confidence with, ICT. Overall, female students declare less frequent use of computers and less confidence than their male counterparts. Males declare that they use ICT frequently, for a wider range of activities and are more likely to use ICT for leisure purposes. Specifically, males appear to play more games and do more programming than females, but their declarations are quite similar for frequency of school-related tasks such as word processing and communication tasks such as sending e-mail and chatting on line. Although males continue to be much more confident about high-level tasks, such as using software to find or get rid of viruses, the average gender difference in OECD countries has decreased significantly since PISA 2003. In fact, declarations regarding high-level Internet tasks to be used in an educational context, such as using a word processor, creating a presentation, or using a spreadsheet to plot a graph, show a difference between females and males of less than 5 percentage points.
- There is a stronger socio-economic difference in students' use of ICT for leisure activities and for academic activities. The difference between students from the bottom and top ESCS quarters is twice as large for Internet and entertainment use as for programmes and software use.
- A profiles analysis, which looks not only at students' gender or socio-economic status but also individual characteristics such as self-confidence in doing ICT activities and performance in the PISA science test, gives a far more nuanced picture of ICT users than the often used dichotomy of the "male gamer" and the "female communicator".

Notes

1. One item present in PISA 2003 (“to help learn school material”) was excluded from PISA 2006.
2. This includes: browse Internet, play games, download software, download music and e-mail or chat rooms.
3. This includes: write documents, use spreadsheets and educational software.
4. The six selected profiles represent almost 90% of all the student population.
5. Initially the possibility was explored of developing three student profiles on three questions: playing games (gamer), collaborating on the Internet (communicator) and using educational software (school activator). However the empirical analysis did not give any consistent support to these three distinctive profiles.
6. PISA 2006 developed an index of economic, social and cultural status (ESCS). The intention was to capture a wide range of “aspects of a student’s family and home background in addition to occupational status” (PISA 2006, p. 335). The index “derived from the following variables: the international socio- economic index of occupational status of the father or mother whichever is higher; the level of education of the father or mother whichever is higher converted into years of schooling ... , and the index of home possessions” (PISA 2006, p. 213). The ESCS is constructed to have an OECD mean of zero and a standard deviation of one. More information about the computation of the ESCS index can be found in PISA 2006 (p. 335).
7. There are different average index score of ESCS between the profiles, and all differences are significant (1% level). For example, digi-wired has an average index score of ESCS 0.56 standard deviations higher than digi-educational and 0.48 standard deviations higher than analogue, whereas digi-zappers have a lower ESCS average than digi-wired, digi-casual and monthly users.
8. The PISA 2006 index of self-confidence in ICT high-level tasks “derived from students’ beliefs about their ability to perform tasks on a computer” (p. 342). The index reflects answers to six questions: how to get rid of viruses, how to edit photographs, how to create a database, how to use a word processor, how to use a spreadsheet, how to create a presentation, how to create a multi-media presentation and how to construct a web page. The index is standardised with a mean of zero and a standard deviation of one.
9. The index is standardised with a mean of zero and a standard deviation of one.

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Chapter 4

Students' use of information and communication technologies and performance in PISA 2006

This chapter explores the complex relationship between ICT use and performance based on two types of analysis. First, it takes a general look at the correlation between students' scores in the PISA 2006 science test and four aspects of ICT use: students' experience with computers, overall use at home and at school, types of computer use, and confidence in performing tasks on a computer. In line with the general focus of this report, this chapter gives special attention to the influence of family background on students' results by controlling for economic, social and cultural status. Second, it analyses in more detail the influence of ICT use on student performance by controlling for other variables measured in PISA which might also affect 15-year-old students' science/mathematics scores, such as students' characteristics, parents' characteristics, household characteristics and school characteristics. In this way it provides a clearer picture of the net influence of ICT use on students' performance in the PISA science test.

Introduction

This chapter looks at the relation between ICT use and students' PISA 2006 science scores. It aims to shed light on the question of the association between ICT use and performance, a central concern of policy makers in recent years. The research on this issue has not been conclusive in terms of positive or negative effects and has not found any direct causal links. Instead, it points to a non-linear, complex relation between ICT and learning, with mediating variables related to individual, family and school factors playing an important role (Balanksat, Blamire and Kefala, 2006; Trucano, 2005; Kulik, 2003).

Use of technology and student performance in the PISA 2006 science test

The relation between the use of technology and student performance is approached through the analysis of students' results in the PISA 2006 science test. In this test, student scores were grouped into six proficiency levels, with level 6 representing the highest scores (and hence the most difficult tasks) and level 1 the lowest scores (and hence the easiest tasks). The grouping into proficiency levels was undertaken on the basis of substantive considerations relating to the nature of the underlying competences in science. Students with less than 334.9 score points on any of the science competences were classified as below level 1. These students are unable to demonstrate the science competences needed for the easiest PISA tasks. Such a low level of science competence can be considered to put them at a serious disadvantage for full participation in society and the economy.

In PISA 2006 a performance difference of 74.7 score points represented one proficiency level on the science scale, while in PISA 2003 one proficiency level was equivalent to 62 score points on the maths scale. This can be considered a comparatively large difference in student performance in substantive terms (*i.e.* the difference between being able to make literal interpretations of the results of scientific inquiry and being able to use scientific concepts and apply them directly). The mean student performance for students in OECD countries is set at 500 points. Of the 30 OECD countries, 20 have scores within 25 points of the OECD average of 500. This represents a closely clustered group of countries, each of which has a mean score very similar to that of a number of other countries.

Table 4.1 indicates what students can typically do (*i.e.* their skills and abilities) at each science proficiency level in PISA 2006.

Table 4.1. **Summary descriptions of the six proficiency levels on the science scale**

Level	Lower score limit	Percentage of students able to perform tasks at each level or above (OECD average)	What students can typically do
6	07.9	1.3% of students across the OECD can perform tasks at level 6 on the science scale	At Level 6, students can consistently identify, explain and apply scientific knowledge and knowledge about science in a variety of complex life situations. They can link different information sources and explanations and use evidence from those sources to justify decisions. They clearly and consistently demonstrate advanced scientific thinking and reasoning, and they demonstrate willingness to use their scientific understanding in support of solutions to unfamiliar scientific and technological situations. Students at this level can use scientific knowledge and develop arguments in support of recommendations and decisions that centre on personal, social or global situations.
5	633.3	9.0% of students across the OECD can perform tasks at least at level 5 on the science scale	At Level 5, students can identify the scientific components of many complex life situations, apply both scientific concepts and knowledge about science to these situations, and can compare, select and evaluate appropriate scientific evidence for responding to life situations. Students at this level can use well-developed inquiry abilities, link knowledge appropriately and bring critical insights to situations. They can construct explanations based on evidence and arguments based on their critical analysis.
4	558.7	29.3% of students across the OECD can perform tasks at least at level 4 on the science scale	At Level 4, students can work effectively with situations and issues that may involve explicit phenomena requiring them to make inferences about the role of science or technology. They can select and integrate explanations from different disciplines of science or technology and link those explanations directly to aspects of life situations. Students at this level can reflect on their actions and they can communicate decisions using scientific knowledge and evidence.
3	484.1	56.7% of students across the OECD can perform tasks at least at level 3 on the science scale	At Level 3, students can identify clearly described scientific issues in a range of contexts. They can select facts and knowledge to explain phenomena and apply simple models or inquiry strategies. Students at this level can interpret and use scientific concepts from different disciplines and can apply them directly. They can develop short statements using facts and make decisions based on scientific knowledge.

Table 4.1. **Summary descriptions of the six proficiency levels on the science scale**
(continued)

Level	Lower score limit	Percentage of students able to perform tasks at each level or above (OECD average)	What students can typically do
2	409.5	80.8% of students across the OECD can perform tasks at least at level 2 on the science scale	At Level 2, students have adequate scientific knowledge to provide possible explanations in familiar contexts or draw conclusions based on simple investigations. They are capable of direct reasoning and making literal interpretations of the results of scientific inquiry or technological problem solving.
1	334.9	94.8% of students across the OECD can perform tasks at least at level 1 on the science scale	At Level 1, students have such a limited scientific knowledge that it can only be applied to a few familiar situations. They can present scientific explanations that are obvious and that follow explicitly from given evidence.

Length of time students have used computers and performance

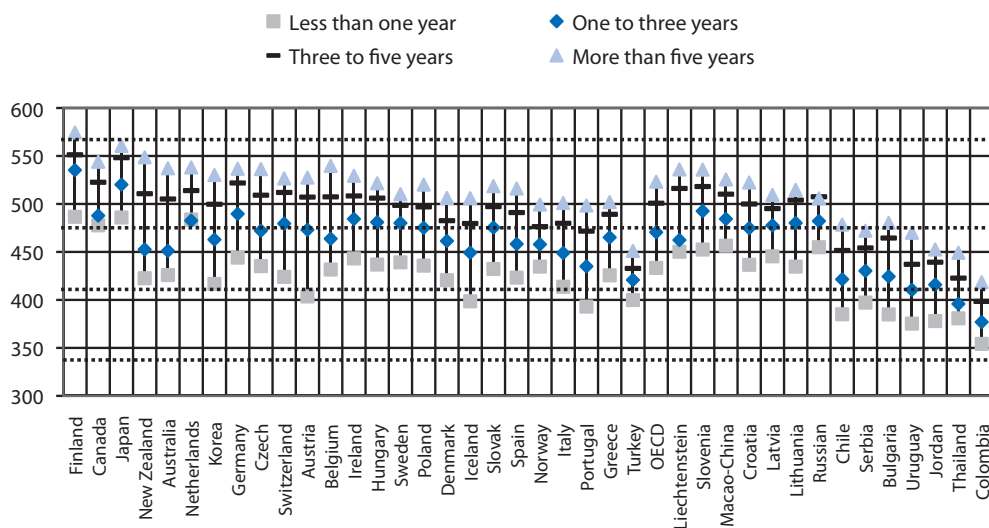
The analysis of PISA 2003 data showed an association between the length of time students had used computers and their performance in mathematics in PISA. Similarly, this section explores the relation between experience using computers and science scores. Chapter 2 showed that in almost all the countries surveyed, the majority of students started using computers at least when they entered secondary education. Nevertheless, the length of time they have used computers differs widely in and across all countries surveyed. It is therefore relevant to explore whether students who have used a computer longer and are more familiar with computers perform differently in the PISA 2006 science test than students who are less familiar with computers and have just started to use them. As Figure 4.1 shows, student performance in science improves with the length of time students have used a computer. Students from OECD countries who have used a computer for more than five years, and are therefore more familiar with computers, perform on average at the middle and higher end of level 3, whereas students who have used a computer for less than one year perform on average at the middle or low end of level 2. On average for OECD countries, the difference between these two groups is 90 score points, more than one proficiency level in the PISA science test. This gap is particularly large in Austria, Belgium, the Czech Republic, Iceland, Korea, New Zealand, Portugal and Switzerland.

A closer look at the data shows that, as for the results in maths scores in PISA 2003, the majority of countries follow a similar pattern: the biggest performance gaps are for students with the least amount of computer experience.

For example, on average among OECD countries, students who have used computers for one to three years perform 37 score points above those with less than one year's experience, while students with more than five years' experience lead those with three to five years' experience by 22 score points. In Austria, there is a particularly large performance gap, of close to one proficiency level, between the two groups of students that are the least familiar with computers (Figure 4.1). Those with less than a year's experience are almost everywhere on average capable of only basic science tasks at levels 1 or 2. Only in Finland and Japan do they reach level 3.

A comparison with PISA 2003 maths results suggests that there is a stronger relation between computer experience and performance in mathematics than with performance in science. The difference between the two groups with the least experience is relatively smaller for the PISA 2006 science performance test than for 2003 mathematics performance test – 37 and 47 score points respectively – and the difference in performance between students with more than five years' experience and students with less a year's experience is almost 100 points in the PISA 2003 maths test and 90 points in

Figure 4.1. **Length of time students have used a computer and mean performance in PISA science scale**



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Countries are ranked in descending order of mean performance on the PISA science scale.

Note: The results for “less than one year” in Australia, Austria, Canada, Denmark, Finland, Germany, Iceland, Korea, Liechtenstein, Netherlands, New Zealand, Norway, Sweden and Switzerland are based on less than 3% of students. This is also the case for “one to three years” in Australia.

the PISA 2006 science test. This difference is even greater when considering that in the PISA maths test one proficiency level was equivalent to 62 score points while in the PISA science test one proficiency level was equivalent to 74.7 score points.

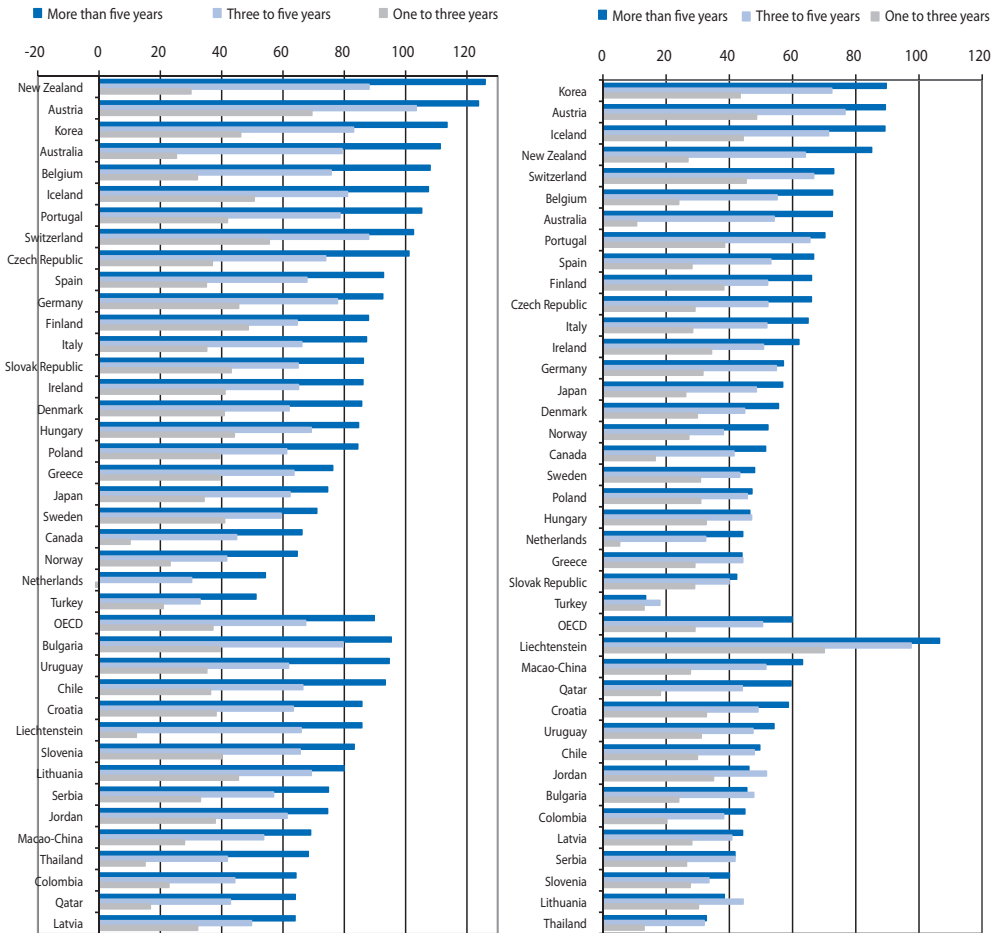
Does socio-economic background explain performance differences for students with different experience using computers?

Higher scores in the PISA 2006 science test among students with more experience using computers may be due to the strong influence that socio-economic background still has for access to ICT resources (see Chapter 2). Nevertheless, when controlling for socio-economic background using the PISA index of economic, social and cultural status (ESCS), results show that performance differences associated with the length of time students have used a computer hold when accounting for socio-economic background. As Figure 4.2a shows, the biggest differences remain between students who have just started using computers (less than a year before the survey) and those who have used computers for at least one year. Compared to students who have used a computer for less than a year and accounting for ESCS, there is on average in OECD countries an advantage of 30 score points for students who have used computers for one to three years, a 51 score points advantage for students who have used computers for three to five years and a 61 score points advantage for students who have used computers for more than five years. In fact, in Australia, Austria, Belgium, Iceland and Korea, accounting for socio-economic background, the performance differences between students who have used a computer for more than five years and students who have used a computer for less than one year remain equivalent to one proficiency level or more on the PISA science scale (Figure 4.2b; Annex A, Table A.10).

In sum, although the data do not prove causality between familiarity with computers and performance, they show that better-performing students are more familiar with computers. Those who have only recently started to use computers (less than one year before the survey) have 433 score points on average, *i.e.* below the OECD average of 500 points, and performance increases with experience with computers.

Figure 4.2. Performance differences on PISA science scale

Observed performance difference in science scale associated with years using a computer Performance difference after accounting for differences in socio-economic background (ESCS)



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Use of computers and student performance

The relation between frequency of computer use and student performance in the PISA 2006 science test

Chapter 3 described students' frequency and type of use of computers at home and at school and identified variables that might explain variations in students' practices. Here, the question of interest is whether the frequency with which students use computers in different places is related to their performance in the PISA science test.

Box 4.1. Frequency of use of computers

As in Chapter 3, this chapter uses the following definitions for frequency of use of computers, based on student responses:

Frequent use: "Almost every day" or "A few times each week"

Moderate use: "Between once a week and once a month"

Rare/No use: "Less than once a month" or "Never"

Figures 4.3a and 4.3b show that the relationship between frequency of use and performance differs substantially depending on students' frequency of use of computers at home or at school. As in PISA 2003, the clearest effect is associated with home use: in every country, students reporting rare or no use of computers at home score below their counterparts who report frequent use (Figure 4.3a and Annex A, Table A.11). In all OECD countries except Turkey, students using computers frequently at home perform at level 3 in the science proficiency scale, while in the majority of OECD countries, students rarely or never using computers at home perform at level 2, with the exceptions of Finland (534), Japan (513), Korea (502), Sweden (494) and Canada (486) where students rarely or never using computers at home also perform at level 3. They also, however, perform below frequent computer users. Among moderate users at home, in the majority of countries their performance on the science proficiency scale is lower than that of frequent users and higher than that of rare or non-users; they perform at the mid-lower end of level 3 and mid-higher end of level 2. There are some exceptions: in Finland, moderate users perform at level 4 on the science proficiency scale and slightly above frequent users. In Korea, moderate users also perform above frequent users, while in the Netherlands and in Turkey they perform below rare or non-users.

Figure 4.3a. Frequency of use of computers at home and student performance on PISA science scale

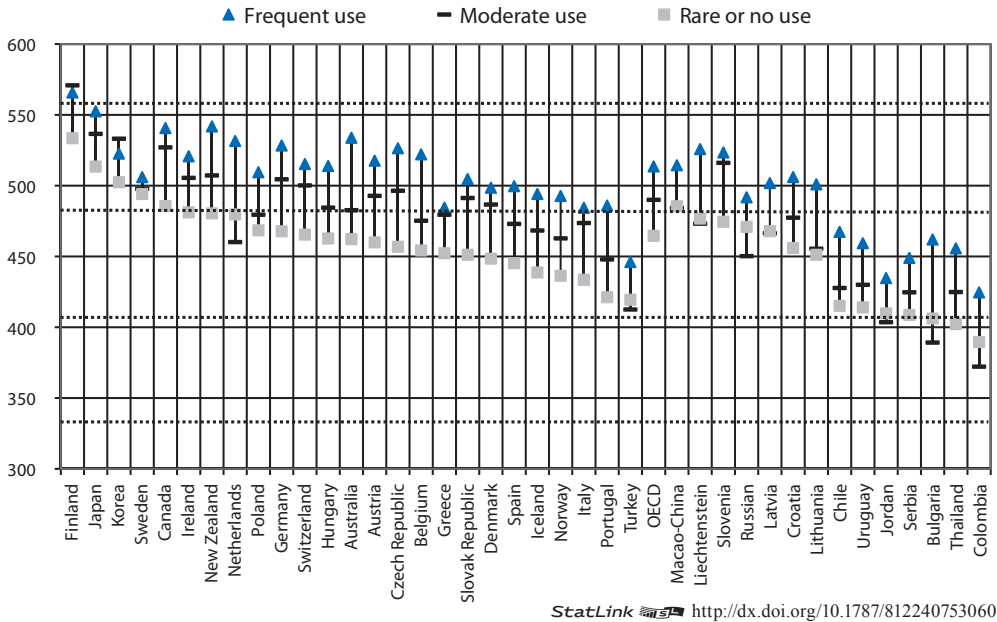
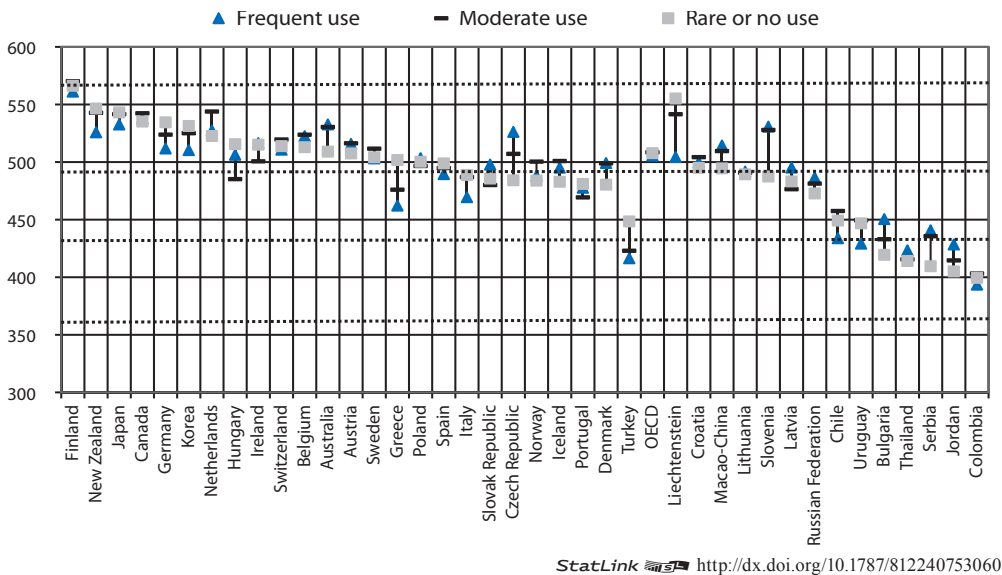


Figure 4.3b. Frequency of use of computers at school and student performance on PISA science scale



For frequency of use at school, the association with performance is less clear. In a majority of OECD countries, students with different frequencies of use at school perform very similarly on the PISA science test. In fact, on average in OECD countries, moderate and rare or non-users score the same (508) and frequent users slightly lower (506). It is interesting that the average score is relatively high (above 500 score points) for the three user frequencies. However, in Finland, Germany, Greece, Italy, Japan, Korea, New Zealand, Spain and Turkey, the finding is the opposite of that for frequency of computer use at home: that is, more frequent computer users perform less well than less frequent users. In Belgium, Canada, Iceland, the Netherlands, Norway, Sweden and Switzerland, moderate users perform better than frequent and rare or non-users (Figure 4.3b, Annex A, Table A.11)

These findings lead to two important observations, which are consistent with the analysis of maths scores in PISA 2003 (OECD, 2006). First, frequency of use at home has a stronger relation with performance on the PISA science test than frequency of use at school; and second, particularly in the case of school use, more computer use does not mean better results in subject-based standardised tests such as PISA 2006. This second observation is consistent with findings in previous studies that show that high amounts of computer use are not always associated with better academic performance. In fact, the results of PISA 2003 showed that the supposition that more frequent use gives better results is not the case in all countries and revealed that students with moderate ICT use had the best results. Previously, Wenglinsky (1998), drawing on data from the 1996 National Assessment of Educational Progress in mathematics for American students in fourth and eighth grades, found that levels of computer use seem not to matter and high levels may even be counterproductive. In another analysis of PISA 2003 data, Fuchs and Woessmann (2004) showed that student performance presents an inverted U-shaped relation with the extent of computer and Internet use at school, rising with some use but falling again with use several times a week.

The evidence suggests that what matters is not so much how much ICT students used but how and for what purposes. Wenglinsky (1998) showed that when computers are used to perform tasks such as applying higher order concepts, and when teachers are proficient enough in computer use to direct students towards more productive uses, computers do seem to be associated with significant gains in mathematics. However, Fuchs and Woessmann (2004) found that when computers are used at home as a communicational and educational device, there is a positive relation with student performance. In another analysis of PISA 2003 data, Papanastasiou and Ferdig (2006) showed that different types of activities performed on the computer are related to different levels and types of thinking, which in turn are associated with very different types of results.

Overall use and performance in science and reading

Considering the above evidence that frequency of use at school does not by itself seem to matter much, and that more frequent computer use at home and at school is not always associated with better performance, it is relevant to consider the relation between what students do with computers and their performance in the PISA science test.

As was done for maths scores in PISA 2003, Chapter 3 developed indices measuring students' overall ICT use on a continuous scale. By relating these to performance, it is possible to analyse the extent to which students who use computers more often across a range of functions tend to do better or worse in the PISA assessment. This cannot reveal the kinds of ICT use that help students to perform better at school, but it does indicate the extent to which students who do well are also those who use ICT for certain purposes. This analysis is based two broad indices of usage: how often students use the Internet and play computer games, and how much they use various computer programmes and educational software. Students in each country are divided into four equal groups according to their scores on each index. Those in the highest usage group are those who frequently use computers for a relatively wide range of purposes; those in the lowest are the least frequent users.

Figures 4.4a and 4.4b show, for each of these two indices, the average science score and the average reading score for students in OECD countries in each category. Although the trends are similar, the levels of use for Internet and entertainment use appear to be less strongly related to average performance both on the PISA science scale and the PISA reading scale than the levels of use for programmes and software. As Figure 4.4a shows, students who use computers the least for Internet and entertainment score on average 7 score points less on the PISA science scale than those in the second quarter of usage, 5 points less than those in the third quarter of usage and the same as those in the quarter of most intensive users. Instead, students who use computers the least for programmes and software score 15 points less than those in the second quarter of usage, 8 points less than those in the third quarter and 19 points more than those in the most intensive quarter of usage (Figure 4.4b).

These results confirm for both indices the findings obtained from the analysis of maths scores in PISA 2003: more use does not mean better academic performance. Results show that, on average, students in the second quarter in both indices score highest in both PISA science and reading tests. On average, the lowest quarter of students and those who use computers frequently for a wide range of purposes also tend to have relatively low average scores, especially in the case of those making wide use of programmes and software. On average in OECD countries, students in the top quarter of users of programmes and software score 34 score points below those in the second quarter of users in science; the difference in reading performance is slightly more pronounced

Figure 4.4a. **Students' use of ICT and OECD average performance in PISA science scale by quarter of the indices**

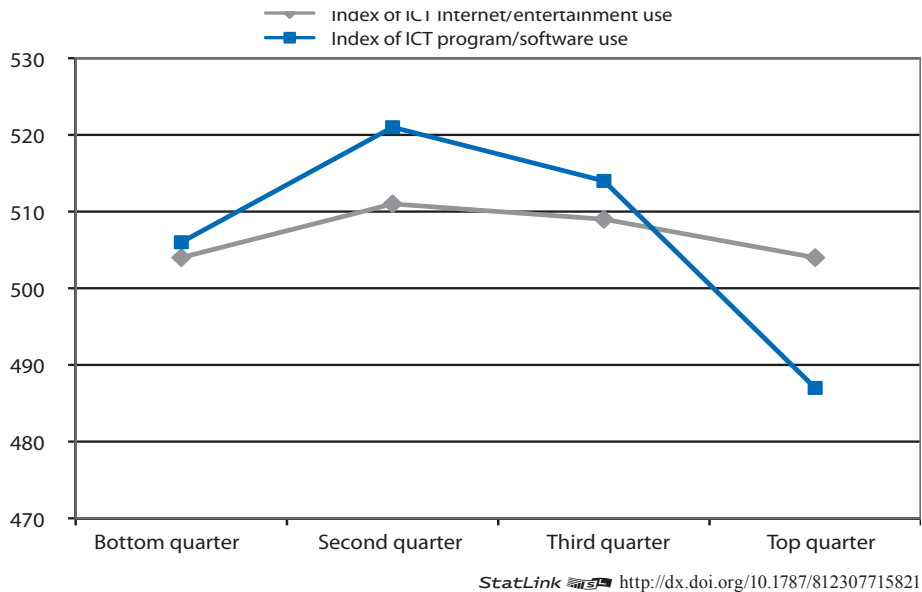
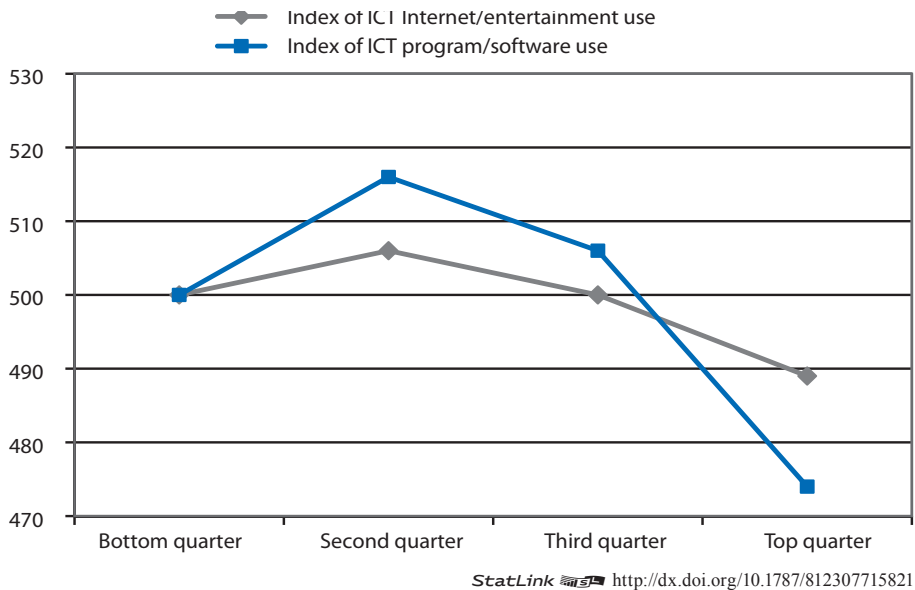


Figure 4.4b. **Students' use of ICT and OECD average performance in reading by quarter of the indices**



(42 score points). While more computer usage is not necessarily more beneficial for students in subject-based assessments such as PISA, this does not imply that higher levels of computer usage might not be beneficial for other types of learning, such as computer literacy or the development of other skills that are not related to subject-based learning. In order to capture these other types of learning, new international instruments should be designed.

Confidence in performing tasks on a computer and student performance in science

Several studies have shown that students' confidence in performing school activities is important for achievement. Therefore, it seems relevant to explore whether students who are more confident in performing certain ICT-related tasks have better results in the PISA 2006 science test. As for maths scores in PISA 2003, the analysis shows a relation between confidence in completing ICT tasks and performance in science. With regard to Internet ICT tasks, such as searching the Internet for information or downloading files or programmes from the Internet, the quarter of students with the greatest confidence score on average 43 score points higher than those with the least confidence (see Table 3.2 in Chapter 3 for a list of routine tasks). Students' confidence in performing Internet tasks on a computer explains 5% of the variance in science performance on average across OECD countries and between 9% and 13% in Hungary, Portugal, the Slovak Republic and Turkey (Figure 4.5a; Table A.10).

Confidence in their ability to perform high-level tasks, such as using software to find or get rid of viruses or creating a database is also positively associated with performance in science (12 score points on average), although the relation is less than half as strong as for the Internet (Figure 4.5b). The relation is particularly strong in Japan and Portugal, with a gap of 65 and 78 score points, respectively, between the students who are the least and the most confident in performing these tasks (Table 4.A.1.2). In sum, although this comparison does not show that feeling more confident when doing ICT-related tasks leads to better science skills, it shows that the two tend to go together.

Assessing the impact of ICT use on PISA scores

The first sections of this chapter aimed to see whether the use of ICT has an impact on student performances and found that it has a positive and significant effect. The effect is not the same for all students. For the same level of computer use, male students with more educational resources and from a higher socio-economic background tend to achieve better performance. This suggests that complementary skills are needed to reap the full benefits of computer use. It also implies that policies to promote ICT use among students will be effective if they are supported by measures to improve complementary skills among low-performing students.

Figure 4.5. **Relation between self-confidence in Internet-related and ICT high-level tasks and science scores**

Figure 4.5a. **Change in the science score per unit of the index of confidence in the Internet ICT tasks**

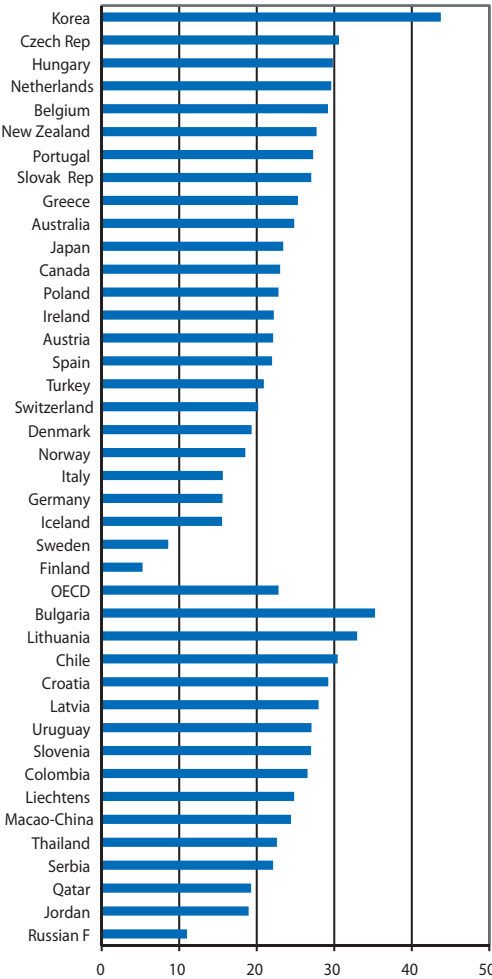
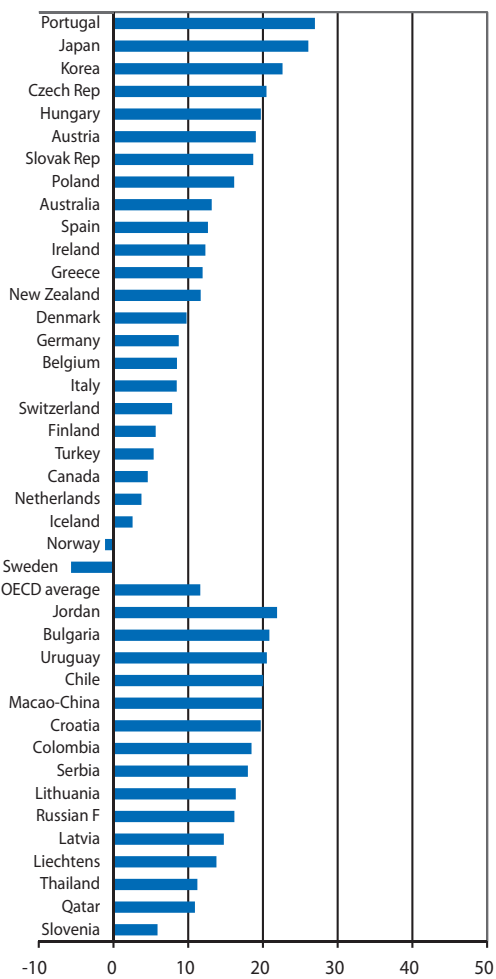


Figure 4.5b. **Change in the science score per unit of the index of self-confidence in ICT high level tasks**



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Introduction

The simplest way to assess the impact of ICT use on student performance is to group students according to frequency of ICT use and to compare the average performances of each group. For instance, if computer users are observed to have better performance than non-users, one could argue that computer use has a positive effect on student performance.

Such a conclusion would be misleading, however, for two reasons. First, students with different characteristics would get different benefits from the same frequency of computer use. Skills, interests and attitudes determine what students do on a computer and how well. Some students would benefit more because they know how to use a computer as a tool for learning, while others would benefit less because they lack the skills necessary to use a computer for educational purposes. Similarly, students interested in school are likely to use the computer for school-related activities. Students with little interest in school would spend more time on computer activities that are not school-related. It is necessary to account for differences in students' skills, interests and attitudes.

The second reason why a simple comparison of computer users and non-users would be misleading is that some factors that affect computer use also affect student performance. For instance, students from advantaged families tend to have readier access to computers than students from disadvantaged families. They also tend to have better school performances. As a consequence, computer users may show better performance because of their socio-economic background. In this case, computer use would capture the effect of family background but would not provide any information on its effects on student performance. To avoid this problem, it is necessary to control for factors that affect both computer use and student performance.

The following sections therefore look at factors that affect the frequency of computer use by students and then identify factors that influence student performances. The impact of computer use is then assessed after having controlled for both sets of factors. Following some further considerations the main policy implications of the analysis are discussed.

What explains ICT use?

ICT use can be measured in several ways. The simplest measure is whether or not a student uses a computer. More interesting indicators are frequency of ICT use, *e.g.* once a week, and the time spent using ICT, *e.g.* one hour a day. Finally, there are measures relating to specific uses of ICT, from broader use, *e.g.* the Internet, to more precise activities, *e.g.* searching the Internet for school-related information. To assess the impact of ICT use calls for a measure both of the specific activities carried out with ICT and of the

time spent on each activity. However, this information is difficult to collect and rarely available from statistical surveys.

The PISA 2006 survey includes questions about the location and frequency of student computer use. It asks students to rate their frequency of computer use at three locations: home, school and other places. Computer use is rated according to five frequencies: “never”, “once a month or less”, “a few times a month”, “once or twice a week” and “almost every day”.

Several studies have pointed out that simple measures of ICT use, such as physical access or frequency of use, are not sufficient to assess the impact of ICT on student performances (Wenglinsky, 1998). What really matters is the degree of “engagement” with ICT. Engagement refers to a situation in which the user exerts a degree of control and choice over the technology, thus leading to a “meaningful use of ICT” (Bonfadelli, 2002; Silverstone, 1996). Engagement, therefore, is about how people relate to ICT in ways that are useful, fruitful and relevant to them (Garnham, 1997; Jung, Qiu and Kim, 2001).

Individuals’ engagement with ICT is based on a complex mixture of social, psychological, economic and pragmatic factors. Some are related to the family and social environment of students; others concern the way each individual interacts with this environment. Several authors (Selwyn, 2004; Murdock, Hartmann and Gray, 1996) have suggested that these factors can be regarded as the result of four different forms of “capital” (Bourdieu, 1997): economic, cultural, social and technological capital (Table 4.2).

Economic capital is probably the most immediate form of capital underlying individuals’ engagement with ICT. Material resources and economic capacity play a central role in determining whether people use ICT and the nature and subsequent patterns of that use. For example, Murdock, Hartmann and Gray (1996) cite the difficulties of using a word processor without a printer or an adequate monitor.

Not only does economic capital imply easier access to a computer at home, it also has an indirect effect through ICT use at school. Students from an advantaged background are more likely to attend schools with better resources, in which access to a computer is easier and teachers are more “engaged” with ICT.

Economic capital cannot account for all stages and levels of engagement with ICT (Murdock, 2002). What individuals can do with ICT is also linked to their level of cultural capital. According to Bourdieu (1993), cultural capital reflects the extent to which individuals have absorbed – often unconsciously – or have been socialised into the dominant culture. Therefore, cultural capital can be embodied (in the form of knowledge), objectified (in the form of books, paintings, instruments and other artefacts), and institutionalised (in the form of qualifications).

The family is one of the main means of transmitting cultural capital. The educational level, profession, cultural orientation and interests of parents have an important impact on students' cultural capital. School is the other main channel not only because of its vocation to transmit codified knowledge but also as a milieu for the diffusion of cultural attitudes.

Many people's engagement with ICT is also influenced by their social capital (Di Maggio and Hargittai, 2001; Fountain, 1997, Jung, Qiu and Kim, 2001). This can involve social obligations or connections between an individual and networks of other individuals (family members, friends), organisations and institutions. As Murdock, Gray and Hartmann (1996) have shown, people's ability to foster, maintain and draw upon social capital in terms of networks of friends, relatives and neighbours was a critical factor in the diffusion of home computing in the United Kingdom. For students, family and school are a powerful channel of socialisation. Because networks tend to be stronger among those with similar social capital, students also tend to socialise with students from a similar economic and cultural endowment: the children of their parents' friends, those who live in the same neighbourhood and go to the same schools.

Finally, some authors have pointed out the fundamental importance of technological capital as a complement to cultural, economic and social capital in the information age (Hesketh and Selwyn, 1999; Howard, 1992). ICT skills and "know-how" as well as access to local sources of technological expertise and material resourcing (e.g. borrowing equipment or sharing/copying software) play a key role in people's engagement with ICT use.

Table 4.2. Different forms of capital

Economic capital	Economic capacity to purchase ICT hardware and software, domestic space for ICT use, material exchanges and resources
Cultural capital	Self-improvement of ICT skills, knowledge and competencies Participation in ICT education and training
Social capital	Engagement with technology use and "techno-culture" via cultural goods, family, peers and other agents of socialisation
Technological capital	Networks of technological contacts and support

Source: Adapted from Selwyn (2004).

Table 4.3. Determinants of computer use

	HEDRES	WEALTH	immigration	white/blue	gender	COMPWEB	RATCOMP	SCHSIZE(*100)	STRATIO(*100)	SCMATEDU	F	N
Australia	0.189	0.415	-0.247	0.106		0.741	0.015				58.98	12 300
	0.018	0.031	0.046	0.044		0.196	0.000					
Austria	0.123	0.316	-0.591	0.237	0.170	0.303					40.99	4 287
	0.022	0.029	0.091	0.053	0.066	0.137						
Belgium	0.215	0.476		0.193			0.001	0.003			88.95	7 513
	0.024	0.038		0.040		0.000	0.000	0.000				
Canada	0.186	0.462	-0.310	0.176		0.902					49.84	16 802
	0.023	0.040	0.060	0.039		0.169						
Switzerland	0.107	0.450	-0.321	0.153	0.179						73.29	10 197
	0.020	0.028	0.060	0.049	0.036							
Chile	0.541	0.434				3.953					357.61	3 511
	0.027	0.029				1.136						
Czech Republic	0.407	0.376		0.160	0.456			0.003			71.99	4 695
	0.033	0.043		0.067	0.057			0.000				
Germany	0.194	0.440	-0.353	0.249	0.483			0.005			81.85	3 738
	0.026	0.036	0.068	0.067	0.045			0.000				
Denmark		0.290		0.489					0.101		39.77	2 766
		0.037		0.062					0.049			
Spain	0.327	0.442		0.185	0.002			0.053			166.08	16 134
	0.019	0.024		0.041	0.000			0.019				
Finland	0.168	0.393		0.358			0.030				66.52	4 163
	0.027	0.034		0.048			0.000					
Greece	0.249	0.420	-0.253	0.513	0.005						137.8	4 129

Table 4.3. **Determinants of computer use** (*continued*)

	HEDRES	WEALTH	immigration	white/blue	gender	COMPWEB	RATCOMP	SCHSIZE(*100)	STRATIO(*100)	SCMATEDU	F	N
	0.026	0.027	0.068		0.043	0.000						
Hungary	0.321	0.371		0.106	0.278		0.658	0.002			89.85	3 955
	0.027	0.030		0.050	0.050		0.142	0.000				
Ireland	0.236	0.431	-0.284								117.64	2 935
	0.023	0.034	0.113									
Iceland	0.139	0.242			0.411				0.063		17.37	3 367
	0.040	0.048			0.069				0.021			
Italy	0.302	0.259			0.393		0.758				226.84	18 133
	0.019	0.024			0.033		0.260					
Japan	0.203	0.168		-0.098	-0.099				0.010		262.66	4 272
	0.018	0.026		0.051	0.043				0.000			
Korea				0.132		0.815	0.027				6.91	4 954
				0.047		0.352	0.000					
Netherlands	0.123	0.322						0.013			25.68	4 102
	0.045	0.052						0.000				
Norway	0.179	0.247		0.252	0.291		0.936				25.95	3 554
	0.042	0.042		0.094	0.061		0.345					
Poland	0.665	0.407			0.455						357.82	4 772
	0.028	0.036			0.041							
Portugal	0.362	0.441			0.260						205.4	4 374
	0.025	0.029			0.052							
Sweden	0.145	0.269			0.396						51.58	3 457
	0.048	0.053			0.064							

Table 4.3. Determinants of computer use (continued)

	HEDRES	WEALTH	immigration	white/blue	gender	COMPWEB	RATCOMP	SCHSIZE(*100)	STRATIO(*100)	SCMATEDU	F	N
Turkey	0.515	0.142	-0.743		0.181		3.130				83.34	2 833
	0.032	0.042	0.220		0.069		1.275					
Bulgaria	0.659	0.549			0.276						166.06	3 529
	0.037	0.045			0.063							
Croatia	0.456	0.263			0.443		1.528				119.33	4 162
	0.030	0.028			0.048		0.652					
Latvia	0.562	0.423						0.034		0.110	145.46	3 956
	0.034	0.039						0.000		0.040		
Lithuania	0.521	0.494		0.131	0.436	0.311					161.87	4 130
	0.035	0.038		0.055	0.052	0.117						
Macao, China	-0.177	0.334			0.309						83.56	4 206
	0.031	0.031			0.050							
Serbia	0.532	0.292		0.237	0.350						217.69	4 018
	0.027	0.035		0.043	0.044							
Slovenia	0.257	0.335	-0.472	0.161	0.362			0.023			41.52	5 564
	0.038	0.038	0.101	0.063	0.046			0.000				
Thailand	0.393	0.275		0.105	0.149		1.323				90.25	4 984
	0.030	0.029		0.048	0.053		0.421					

Note: Standard errors on the white row. All estimates significant at 1% except: significant at 5%

The same frequency of ICT use can thus have different effects on students' performance depending on their capital. To assess the impact of ICT, it is therefore necessary to measure both the frequency of ICT use and each student's level of capital. By definition, this cannot be observed. Nonetheless, the above discussion has highlighted factors that play a role in the accumulation of capital: economic and cultural resources, personal characteristics, school resources, and ICT access. These indicators can be used to estimate individual students' level of capital.

The same statistical model (Ordered Probit, [below indicated as OLS] see Annex C for details) was used for each of the 33 countries – 23 OECD and 10 partner countries – that filled out the ICT survey. The model produces two sets of results. First, it estimates the level of capital of each student based on a number of relevant indicators. Second, it estimates the frequency of computer use of each student as a function of his/her capital.

The PISA 2006 surveys contain several indicators that can be used as a proxy for the different types of “capital”. These are used to explain the determinants of computer use at home and at school. Computer use in other places was not considered both because it accounts for a very small percentage, particularly in OECD countries, and because the type of use is likely to be more diverse than at home and at school and less related to education.

The frequency of computer use at home and at school tends to be closely connected. On the one hand, students from a better-endowed family – in terms of any of the forms of capital considered above – tend to have a higher frequency of computer use at home and to attend schools with higher ICT use. On the other hand, computer use at school is likely to increase students' interest in ICT and skills so that ICT use at home would also increase. For these reasons, computer use at home and at school can be analysed together.

Initially, all variables available in PISA which could be related to determinants of computer use based on previous studies were included: gender, immigration, computer possession, family wealth, educational attainments of parents, etc. Then, variables that were not statistically significant were dropped, one at a time, starting with the least significant. Final results are reported in Table 4.3. One or more of the following variables were found to affect computer use.

Household characteristics

- Wealth of the student's family
- Educational resources available at a home

Parents' characteristics

- Parents' occupation

Student's characteristics

- His/her immigration status
- His/her gender

School characteristics

- Number of teachers per student
- Quality of educational resources
- Size of the school

ICT access in school

- Number of computers per student
- Percentage of school computers connected to the Internet

Family wealth, educational resources at home and gender appear to be significant determinants of computer use in a great majority of countries. Parents' occupation and immigration tend to be relevant in a large number of cases. Educational resources and ICT equipment in school also appear to play a role, although their effect is captured by a different set of indicators in different countries.

The wealth of the student's family is measured by an index (WEALTH) that combines answers about the number of cellular phones, televisions, cars and other country-specific wealth items possessed by the family (Table 4.4). A wealth index was chosen over an income variable because previous studies have shown that household possessions are a more reliable indicator of family wealth. In all countries, the wealth index has a positive sign: the greater the wealth of the student's family, the more he/she tends to use a computer.

The items "computer" and "a link to the Internet" are part of the wealth index. Interestingly enough, these two variables were not statistically significant, either alone or together. This suggests that possession of a computer and/or a link to the Internet is not sufficient to make a difference in terms of frequency of computer use. They have an effect only for students from wealthy families.

Home education resources are also measured by an index (HEDRES) composed of various items such as a study room, calculator, books, a computer for schoolwork and educational software (Table 4.4). The sign of the index is always positive: more educational resources tend to result in greater computer

use. Again, neither the possession of a computer for schoolwork nor the availability of educational software had a significant effect alone. These items seem to make a difference only together with a broader set of educational resources.

The occupational status of the parents has also a significant impact on the frequency of computer use. Students' families were classified into “white-collar” and “blue-collar”, according to the highest occupational status of the two parents. The positive sign of this variable shows that children of white-collar parents tend to use computers more frequently than the children of blue-collar parents.

Table 4.4. Items included in PISA indices: WEALTH, HEDRES and HOMEPOS

		Item is used to measure index		
		WEALTH	HEDRES	HOMEPOS
Q13	In your home, do you have			
ST13Q01	A desk to study at		X	X
ST13Q02	A room of your own	X		X
ST13Q03	A quiet place to study		X	X
ST13Q04	A computer you can use for schoolwork		X	
ST13Q05	Educational software		X	X
ST13Q06	A link to the Internet	X		X
ST13Q07	Your own calculator		X	X
ST13Q08	Classical literature (e.g. <Shakespeare>)			X
ST13Q09	Books of poetry			X
ST13Q10	Works of art (e.g. paintings)			X
ST13Q11	Books to help with your schoolwork		X	X
ST13Q12	A dictionary		X	X
ST13Q13	A dishwasher (country-specific)	X		X
ST13Q14	A <DVD or VCR> player (country-specific)	X		X
ST13Q15	<Country-specific wealth item 1>	X		X
ST13Q16	<Country-specific wealth item 2>	X		X
ST13Q17	<Country-specific wealth item 3>	X		X
Q14	How many of these are there in your home?			
ST14Q01	Cellular phones	X		X
ST14Q02	Televisions	X		X
ST14Q03	Computers	X		X
ST14Q04	Cars	X		X
Q15	How many books are there in your home			X

The immigration variable measures the difference in computer use between native-born and immigrants. Its negative sign indicates that first- and second-generation immigrants are more likely than native-born to have higher computer use.

Finally, the sign of the gender variable is also positive, indicating that males use computers more frequently than females.

The second group of variables measures access to ICT and educational resources in schools.

The number of teachers per student (STRATIO) and the quality of educational resources (SCMATEDU) provide a measure of the educational resources at school. The latter is an index based on the self-evaluation of the school principal. Both indicators have a positive and significant effect, suggesting that schools with better educational resources tend to promote ICT use among students.

The size of the school (SCHSIZE) also has a positive and significant impact on computer use. This may be an indication that large schools are proportionally better equipped with ICT than small ones, *e.g.* schools in urban versus rural areas – or it may be due to an “economy of scale” in terms of computer access: as not all students use the computer at the same time, the larger the number of computers available in a school, the higher the probability of finding one available.

Finally, both the number of computers per student (RATCOMP) and the number of computers connected to the Internet (COMPWEB) seem to increase computer use among students in some countries.

What explains student performance?

PISA assesses the extent to which students near the end of compulsory education have acquired the knowledge and skills that are essential in everyday life. Students are tested on reading and on mathematical and scientific literacy and complete a background questionnaire. In this study, the focus is on student performance in science. Nonetheless, the scores of the three tests are highly correlated, so that the results presented for science can be generalised, at least in their broad lines, to maths and reading as well.

The same statistical model (OLS, see Annex C for details) was used to explain science scores in each of the 33 countries – 23 OECD and 10 partner countries – that filled out both the general PISA survey and the ICT module. Initially all variables available in PISA which, on the basis of previous studies, could be related to determinants of science performance were included. In addition, frequency of computer use and the previously estimated measure of students' capital were also included. Variables that were not statistically

significant were dropped one at a time, starting with the least significant. The final results are reported in Table 4.5. In most countries, the variables that affect PISA science scores are:

Students' characteristics

- Gender
- Immigration status
- Interest in science
- Motivation to continue learning about science

Parents' characteristics

- Science-related carrier
- Educational attainments
- Occupation

Household characteristics

- Home possession.
- Educational resources
- Number of books at home

School characteristics

- Number of teachers per student
- Size of the school
- Quality of educational resources

Frequency of computer use

- Associated with the “average” level of students’ capital
- Associated with the “marginal” level of students’ capital

The first set of factors is related to students’ characteristics. The gender variable measures the difference in science scores between males and females. The variable has a positive sign, showing that males tend to have higher scores than females, when controlling for all other differences.

Table 4.5. Determinants of science scores

	Gender	PARSCI	Immigration	HOMEPOS	HEDRES	HISEI	PARED	INTSCIE	SCIEFUT	Books	STRATIO	SCHSIZE	SCMATEDU	F	R2	N
Australia					10.892	1.002	3.245	10.834	17.890	37.060		0.012	6.966	255.89	0.25	12 226
					1.434	0.068	0.553	1.159	1.132	1.652		0.004	1.664			
Austria	6.993	<u>73.185</u>				0.763		15.754	8.184	44.384		0.044		65.90	0.36	4 328
	3.751	7.909				0.098		2.040	2.004	2.938		0.010				
Belgium	9.814	6.909	62.558	21.187	7.960	1.093		14.485	13.798	15.642	-0.006			135.94	0.30	7 405
	3.651	2.581	5.452	5.472	2.044	0.084		2.047	1.448	3.112	0.001					
Canada	11.361	8.579	15.621		4.934	1.053		10.071	16.473	34.776		0.008		118.30	0.21	16 698
	2.076	2.505	3.977		1.466	0.065		1.489	1.150	2.182		0.003				
Switzerland	15.962		40.737	20.355		0.921	2.887	21.212	9.646	25.515		0.017	8.107	128.96	0.36	10 124
	2.814		4.175	4.328		0.085	0.491	1.540	1.413	2.873		0.005	2.138			
Chile	17.228	<u>11.621</u>	38.907			0.799	2.703	5.278	6.149	29.919			10.325	37.07	0.25	3 446
	3.411	5.170	15.289			0.128	0.503	1.598	1.641	4.513			3.702			
Czech Republic	20.151	12.373	39.240	<u>8.941</u>	20.864	1.699	12.678	<u>4.728</u>		37.036		<u>0.034</u>		55.92	0.24	4 652
	6.647	3.631	11.712	4.842	4.450	0.143	1.979	2.069		4.237		0.016				
Germany	20.729	11.876	44.634	<u>8.088</u>	6.894	0.793	2.822	16.403	7.640	31.265	-0.001	0.041		71.29	0.32	3 690
	4.842	3.158	6.117	3.715	1.883	0.104	0.474	2.068	1.589	3.178	0.000	0.008				
Denmark	26.954		51.428	17.546		0.716	1.950	19.059	8.206	26.775	-0.002			66.67	0.27	2 714
	5.539		8.359	3.897		0.114	0.768	1.754	1.902	4.559	0.001					
Spain	26.135		34.127	27.991	24.784	0.787	1.811	10.663	12.378	20.704			6.272	139.46	0.25	15 931
	2.917		5.792	4.553	2.098	0.080	0.344	1.186	1.242	2.670			1.994			
Finland	26.193	5.876	79.101	25.336		0.511	1.660	17.518	16.380	19.485		0.034		101.29	0.24	4 122
	4.254	2.288	17.189	4.622		0.088	0.543	1.819	1.750	3.094		0.010				
Greece		<u>7.967</u>	26.673		23.993	0.773	3.341	15.449		21.824			<u>6.751</u>	45.96	0.25	4 112

Table 4.5. Determinants of science scores (continued)

Gender	PARSCI	Immigration	HOMEPOS	HEDRES	HISEI	PARED	INTSCIE	SCIEFUT	Books	STRATIO	SCHSIZE	SCMATEDU	F	R2	N
	3.579	8.197		2.412	0.120	0.596	1.374		2.632			3.222			
Hungary	13.244	<u>6.394</u>		17.134	0.838	6.717	14.707		35.824				69.69	0.28	3 931
	3.339	2.999		2.578	0.126	0.756	2.053		3.057						
Ireland	11.891		20.053	8.933	0.829	1.843	13.224	15.288	30.610		0.032		56.03	0.26	2 918
	3.817		4.979	2.782	0.109	0.714	1.954	1.984	4.000		0.010				
Iceland	51.939	72.096	20.577	18.876	0.662	3.520	13.089	17.490	21.176			6.130	67.44	0.27	3 323
	10.491	12.931	5.888	2.571	0.103	0.530	1.965	2.306	3.883			1.549			
Italy	18.562	32.466		17.738	0.826	0.938	15.859		35.148		0.022		54.92	0.19	17 712
	5.123	5.836		3.668	0.087	0.395	1.319		2.482		0.005				
Japan			14.199	14.855	0.552	7.628	20.185	13.799	9.886		0.034	<u>6.006</u>	56.95	0.24	4 262
			3.764	3.436	0.124	0.831	1.779	1.951	3.360		0.008	2.827			
Korea			4.923	6.267	0.306	2.205	23.289	8.980	27.646				41.66	0.22	4 951
			1.870	1.671	0.102	0.653	1.697	2.376	3.236						
Netherlands	8.230	9.885	48.192	18.670	9.095	1.182	14.292	8.981	20.609	-0.004	0.041		115.14	0.33	3 978
	2.946	3.026	6.738	4.727	1.976	0.115	1.756	1.826	3.781	0.002	0.006				
Norway	14.544	6.622	33.115		10.271	1.012	20.678	5.159	35.721				73.21	0.22	3 499
	3.996	2.809	7.328		2.618	0.109	1.534	2.017	3.208						
Poland	44.738		31.426	58.852	0.627	7.382	12.997		17.946	-0.002	0.021		0.20	54.67	4 751
	4.148		3.516	5.286	0.113	0.893	1.749		3.123	0.000	0.009				
Portugal	19.285	12.727	34.977	25.786	17.124	1.147	8.125	16.345	<u>7.584</u>		0.030		68.81	0.29	4 320
	3.450	3.975	7.052	4.873	3.187	0.090	2.145	1.630	3.733		0.005				
Sweden	20.352		48.802		5.773	1.166	20.212	10.879	36.047		<u>0.026</u>		81.47	0.27	3 407
	4.104		4.594		2.041	0.082	2.122	1.849	3.246		0.012				

Table 4.5. Determinants of science scores (continued)

	Gender	PARSCI	Immigration	HOMEPOS	HEDRES	HISEI	PARED	INTSOIE	SCIEFUT	Books	STRATIO	SCHSIZE	SCMATEDU	F	R2	N
Turkey					21.533	0.795		12.761	6.199	22.482				16.82	0.26	2 818
					9.048	0.135		2.086	2.072	4.482						
Bulgaria	34.188	10.248		54.466	55.134	0.925	2.123	7.390		18.532	-0.003	0.073		27.74	0.33	3 514
	4.791	4.222		5.884	4.727	0.125	0.812	1.783		4.258	0.001	0.011				
Croatia	41.987	9.875	7.962	22.896	38.163	1.082	15.901			20.027		0.025		37.21	0.20	4 095
	7.867	3.019	3.877	4.420	6.861	0.108	1.886			3.900		0.008				
Latvia				23.453	38.641	0.903			6.863	22.226		0.029		51.85	0.15	3 940
				5.821	7.439	0.138			2.048	3.661		0.010				
Lithuania	20.000	8.265		26.928	39.070	0.884	1.424	16.618		25.296			7.587	36.16	0.23	4 109
	6.055	3.409		5.587	5.511	0.101	0.612	2.007		3.409			3.346			
Macao, China	24.063		-13.576	18.709	20.613	0.391	0.990	19.406			-0.004		9.770	57.26	0.16	4 148
	4.466		2.667	4.097	2.597	0.107	0.484	1.622			0.001		1.409			
Serbia	15.173	12.280	-13.784	14.338	26.724	1.175	6.991			22.889				36.82	0.16	3 932
	5.965	3.522	4.641	3.759	6.134	0.095	1.593			3.606						
Slovenia	35.496	7.016		21.380	18.124	1.019	3.913	12.459	8.927	23.861	-0.005	0.100		95.18	0.34	5 535
	3.708	3.477		2.826	2.651	0.114	0.788	1.860	1.586	3.930	0.003	0.004				
Thailand		26.395	66.778		14.093	0.437	1.189	15.949		11.928	-0.004	0.010	6.513	96.97	0.27	4 892
		6.637	21.669		4.023	0.106	0.484	1.662		3.545	0.000	0.003	2.140			

Note: Standard errors on the white row. All estimates significant at 1% except: significant at 5%.

The immigration variable measures the difference in science scores between native-born and immigrants. Its negative sign indicates that first- and second-generation immigrants tend to have lower science scores than the native-born.

Two science indices were added to the model. The 2006 PISA dataset has nine science indices related to attitudes and perceptions of science. The two that were significant – and positive – are an index measuring student interest in science (INTSCIE), and another measuring student motivation to continue learning about science or pursuing a science-related career in the future (SCIEFUT). Students with a stronger interest in science tend to have better scores in science.

The second set of variables is related to parents' characteristics. A first variable measures whether either parent has a science-related career (PARSCI). A positive sign indicates that students will have better science scores if one of their parents has a science-related career.

Parental education is a second family background variable that is often used in the analysis of educational outcomes. It is measured by the largest number of years in education of either parent (PARED). The findings show that longer parents spent in education, the higher the expected science scores of their children.

Parents' occupations are classified according to the level and specialisation of the skills they have acquired, based on the International Standard Classification of Occupations (ISCO-88). The higher the skills content of the occupation of either parent (HISEI), the higher the expected science scores of his/her children.

The third set of variables measures household characteristics. In PISA 2006, students reported on the availability of 13 different household items at home. In addition, countries added three specific household items that were seen as appropriate measures of family wealth in that country. The index home possessions (HOMEPOS) is based on the availability of these household items. Home possessions have a positive impact on science scores, as shown by its positive sign.

Home educational resources are measured by an index (HEDRES) composed of various school items such as a study room, calculator, books, a computer for schoolwork and educational software. The sign of the index is always positive: more educational resources tend to result in higher science scores.

PISA 2006 reports interesting information about the number of books in a household. It was found that students from households with a large number of books (over 100) tend to achieve better scores in science. The role of this factor appears even stronger when one considers that the number of books also enters the home possessions index.

The last set of variable looks at the characteristics of the school. The number of teachers per student (STRATIO) and the quality of educational resources (SCMATEDU) provide a measure of the school's educational resources. The latter is an index based on the self-evaluation of the school principal. Both indicators have a positive and significant effect: students in schools with better educational resources tend to have higher scores in science.

School size (SCHSIZE) also turned out to have a positive and significant impact on science scores. As discussed above, this may indicate that large schools, *e.g.* schools in urban versus rural areas, are proportionally better endowed with physical and human resources, or it may be due to an "economy of scale" in the use of educational resources: as not all students use libraries, laboratory, tutors, etc., at the same time, students in larger schools would benefit more from a same stock of educational resources per capita.

Does ICT use improve student performance?

The last two variables look at the impact of computer use on student performance in science. The first variable is frequency of computer use, measured at the "average" level of students' capital. As the impact of computer use varies with capital and students with the same frequency of use have different levels of capital, this variable makes it possible to estimate the "average" impact for each frequency of use.

Columns 1 to 4 in Table 4.6 show the estimated increase in average science scores due to computer use. The first column shows the estimated increase from using a computer once a month as compared to never. The second column shows the estimated increase from using computer a few times a month as compared to never. And so on.

For instance, the first row shows that, on average, Australian students would increase their science scores by 8 points by using a computer once a month or less, by 51 point by using it a few times a month, by 76 point by using it once or twice a week, and by 105 points by using it almost every day.

A higher frequency of computer use is associated with higher average science scores in all countries considered. Among OECD countries, the largest effect of using a computer almost every day was found in Iceland, Japan, the Netherlands, Norway, Poland and Spain. Among partner countries, the largest effect of using computer almost every day was found in Bulgaria; Macao, China; and Slovenia. It is important to recognise that these figures cannot be compared across countries. In fact, the effect of computer use is estimated for the average level of students' capital, and this level is likely to vary across countries.

Table 4.6. Average increase in science scores due to computer use

	Average				Differential
	Once a month or less	A few times a month	Once or twice a week	Almost every day	
Australia	8	51	76	105	-24.31
	37.02	16.17	17.37	18.20	3.56
Austria	50	63	60	79	-4.37
	17.70	13.41	13.80	13.87	5.32
Belgium	71	93	135	162	-38.19
	25.47	29.80	34.84	40.60	12.00
Canada	49	60	84	102	-17.06
	19.92	18.95	19.53	21.17	4.02
Switzerland	56	103	153	197	-54.32
	26.19	27.90	30.64	34.77	8.30
Chile	ns	ns	ns	ns	ns
	28.99	22.97	27.74	34.34	12.49
Germany	52	44	59	99	-29.85
	37.97	12.68	16.27	22.93	8.90
Denmark	72	187	196	218	37.16
	36.70	39.09	41.22	45.00	9.09
Spain	121	202	259	327	-93.75
	14.19	21.79	26.56	32.18	9.60
Finland	112	175	218	270	-60.89
	26.15	31.40	35.13	42.19	10.22
Greece	35	38	44	56	-20.14
	11.98	13.30	14.72	17.64	4.96
Hungary	27	49	76	87	-17.09
	31.25	24.93	23.30	24.27	5.74
Ireland	89	149	182	239	-63.49
	19.17	26.05	31.13	38.45	10.17
Iceland	353	478	549	648	-157.17
	74.64	81.45	92.53	104.01	24.62
Italy	71	102	110	120	-23.10
	22.65	29.67	33.82	39.63	10.93
Japan	128	218	281	392	-90.38
	25.63	39.53	51.79	70.13	17.26

Table 4.6. Average increase in science scores due to computer use
(continued)

Korea	89.50	153.86	178.78	191.76	-50.36
	42.18	57.73	65.67	76.46	20.64
Netherlands	187	204	255	282	-64.51
	79.93	53.22	53.23	57.52	12.95
Norway	171	214	262	284	-38.19
	40.07	38.01	42.19	44.79	8.19
Poland	136	195	251	322	-91.34
	18.55	22.56	26.58	32.92	8.94
Portugal	107	161	207	244	-53.03
	20.98	27.85	31.15	37.38	9.81
Sweden	136	184	204	214	-36.30
	42.97	47.70	48.45	49.93	6.78
Turkey	26	18	23	20	-14.02
	21.63	34.84	40.76	55.65	19.41
Bulgaria	117	212	275	354	-95.95
	26.09	25.18	27.08	33.78	8.76
Croatia	128	213	247	302	-86.43
	27.16	39.23	45.29	53.37	17.35
Latvia	99	162	219	264	-60.37
	28.15	38.20	47.15	58.25	14.69
Lithuania	97	148	198	250	-61.87
	23.92	31.45	35.34	44.65	12.68
Macao, China	83	236	292	356	-71.50
	30.05	33.04	40.52	47.58	11.62
Serbia	72	142	176	200	-42.68
	33.30	37.38	42.87	48.01	12.58
Slovenia	129	226	284	334	-80.21
	33.08	34.77	38.84	40.20	7.96
Thailand	21	18	25	25	-2.08
	10.55	9.20	8.05	8.15	7.93

Note: Standard errors on the white row. All estimates significant at 1% except: significant at 5%.

The second variable for measuring the effects of ICT on science scores is the frequency of computer use associated with each student's level of capital. As not all students with a given frequency of computer use have the same level of capital, this effect will differ. In particular, it would be higher than average if a student has a level of capital above the average and lower than average if the student has a level of capital below the average. For each student, therefore, the increase in the science score due to computer use would be the sum of two parts: the "average" increase plus the "differential" increase due to the difference from the "average" capital.

The last column of Table 4.6 shows the estimated "differential" effect of computer use. This effect is positive in all countries: if a student uses a computer almost every day but has a level of capital below the "average", the increase in his/her science score would be smaller than the "average" increase.

These results are illustrated in Figure 4.6. Science scores are plotted on the vertical axis and computer use on the horizontal axis. The red dots show the "average" science score associated with the corresponding frequency of computer use, measured at the "average" level of students' capital. The line joining these dots shows the average increase in science score due to higher computer use.

The vertical dotted lines corresponding to each frequency of computer use show the "differential" effect of computer use on science scores for a student with a level of capital above or below the "average". For instance, the points below the red dot corresponding to "almost every day" show that, among all students using the computer almost every day, those with a lower capital have also lower than the "average" science scores. Similarly, the points above the red dot corresponding to "never" show that, among all students not using the computer, those with a higher level of capital also have higher science scores.

School or home: does it make a difference?

An interesting question is whether the effects of ICT on student performance are different when ICT is used at home or at school. ICT use at school can be expected to be prepared by some training, to be more closely related to educational activities, and to benefit from the expertise of a teacher (Wenglinsky, 2002). ICT use at home may be more related to leisure activities and not benefit from any formal training (Fuchs and Woessmann, 2004). In addition, students using a computer at home are likely to be more interested in ICT, have more scope for experiment and self-learning, and can search and discover the resources – both software and web content – that are best suited to their needs (Ravitz, Mergendoller and Rush, 2002; Valentine *et al.*, 2005; OECD, 2006).

Table 4.7. Average increase in science scores due to computer use: at home and at school

	At home				At school			
	Once a month or less	A few times a month	Once or twice a week	Almost every day	Once a month or less	A few times a month	Once or twice a week	Almost every day
Australia	<i>ns</i>	63	86	109	<i>ns</i>	51	61	101
		20.017	17.140	18.157		17.753	17.715	17.608
Austria	33	56	52	76	78	59	50	79
	22.496	14.522	13.191	13.654	22.653	18.508	14.698	16.567
Belgium	114	119	162	202	66	110	148	174
	30.261	24.319	25.583	29.426	23.717	27.061	26.456	31.981
Canada	43	91	92	106	47	43	66	92
	20.998	19.652	19.944	21.394	23.281	19.437	20.559	23.178
Switzerland	<i>ns</i>	81	117	159	<i>ns</i>	57	106	142
		14.244	18.917	23.969		19.559	18.472	24.428
Chile	<i>ns</i>	<i>ns</i>	<i>ns</i>	<i>ns</i>	<i>ns</i>	<i>ns</i>	<i>ns</i>	<i>ns</i>
Czech Republic	<i>ns</i>	52	108	138	<i>ns</i>	64	101	148
		22.703	28.919	35.996		23.858	27.976	34.508
Germany	53	61	85	120	<i>ns</i>	32	56	84
	14.152	16.418	17.813	24.389		17.150	18.884	33.573
Denmark		139	140	159		148	115	148
		44.200	30.089	31.960		37.978	33.548	36.269
Spain	147	224	286	353	120	209	266	326
	19.369	23.357	27.317	32.939	14.825	21.407	27.022	34.280
Finland	95	209	251	303	111	179	225	251
	36.249	34.205	33.812	40.695	28.988	30.717	36.238	42.770
Greece	<i>ns</i>	35	45	50	33	32	28	<i>ns</i>
		6.965	6.119	5.985	9.462	9.801	6.130	
Hungary	<i>ns</i>	<i>ns</i>	<i>ns</i>	<i>ns</i>	<i>ns</i>	<i>ns</i>	<i>ns</i>	<i>ns</i>
Ireland	119	177	216	281	74	167	197	279
	20.671	26.327	31.327	38.330	20.282	29.898	30.694	39.662
Iceland	390	485	567	671	246	494	531	618
	69.892	80.306	90.645	100.139	74.433	80.580	90.162	106.816
Italy	61	105	106	118	68	96	98	95
	24.823	30.644	34.069	39.352	25.509	28.756	33.675	40.303
Japan	138	231	302	410	133	218	286	385
	28.342	44.764	58.709	79.211	29.495	43.869	57.998	78.535
Korea	88	153	178	188	88	148	164	196
	42.040	58.211	76.491	76.491	42.040	60.484	65.630	75.750

Table 4.7. **Average increase in science scores due to computer use: at home and at school**
(continued)

	At home				At school			
	Once a month or less	A few times a month	Once or twice a week	Almost every day	Once a month or less	A few times a month	Once or twice a week	Almost every day
Netherlands	77	210	271	289	227	221	220	273
	48.950	58.193	55.237	59.349	90.637	59.846	54.704	59.346
Norway	198	208	261	280	152	210	253	283
	33.520	43.336	42.512	45.126	46.472	38.595	44.241	46.605
Poland	160	231	293	367	146	217	276	333
	36.008	27.784	29.852	34.641	20.332	23.039	26.993	38.326
Portugal	204	218	272	318	133	199	249	287
	18.994	33.595	30.572	35.227	21.429	26.116	28.617	34.776
Sweden	118	181	211	215	129	203	185	221
	54.820	48.629	47.921	49.895	49.119	50.195	52.795	50.406
Turkey	3	12	15	14	27	13	20	10
	26.897	36.310	40.730	55.321	21.023	35.998	40.888	57.408
Bulgaria	<i>ns</i>	198	259	358	126	205	268	327
		29.620	29.366	33.409	21.532	23.381	25.699	35.298
Croatia	159	246	284	339	147	222	260	297
	27.838	40.149	45.957	54.139	27.200	39.432	45.624	56.359
Latvia	58	158	208	261	93	154	209	249
	26.685	44.732	46.066	57.609	29.068	37.134	45.998	55.771
Lithuania	102	154	225	275	105	166	209	266
	38.816	31.998	38.670	46.750	23.801	32.341	35.906	46.002
Macao, China	<i>ns</i>	218	247	310	<i>ns</i>	181	235	318
		28.166	33.234	38.833		33.751	32.614	40.985
Serbia	<i>ns</i>	141	201	225	90	162	190	167
		48.669	40.008	42.830	32.247	32.688	37.876	49.177
Slovenia	121	222	268	333	154	225	284	336
	35.485	36.513	40.893	40.522	43.335	38.527	39.303	40.905
Thailand	<i>ns</i>	<i>ns</i>	<i>ns</i>	<i>ns</i>	<i>ns</i>	<i>ns</i>	<i>ns</i>	<i>ns</i>

Note: Standard errors on the white row. When the difference between school and home is statistically significant the corresponding value appears in bold.

To explore whether computer use occurs at school or at home and whether the effects on science scores vary with location, the location of computer use is here defined according to the location of the highest frequency of use, as students may use a computer both at home and at school. A student who uses a computer once a week at home and almost every day at school is defined as using a computer at school.

Table 4.7 shows the estimated increase in “average” science scores due to computer use at home and at school. While the findings are less clear, some patterns can be identified. In particular, in a large majority of countries, the benefits from higher computer use tend to be greater at home than at school. Therefore, despite the better environment and support that schools are expected to provide, computer use tends to have less impact at school than at home.

These differences are statistically significant only in some countries. In Canada, Finland, Germany, Iceland, Japan, Poland, Portugal and Spain and in partner country Croatia the effect of computer use at home is significant for almost all frequencies of use. In Belgium, Greece and Italy and in partner countries Bulgaria and Serbia, the difference in favour of home is significant only at high frequencies of computer use.

For other countries, the lack of statistically significant findings does not necessarily imply that differences between school and home are negligible. It may be due to the fact that frequency hides a significant variation in the actual use of ICT and to the relatively small number of observations available when uses are split among locations. In addition, as mentioned above, other studies based on different methodologies have suggested that computer use matters more at home than at school. Moreover, the larger effect of computer use at home appears too generalised to be dismissed. In sum, although there was no clear answer to this question, there is evidence that the benefits of computer use at school, as compared to use at home, should not be taken for granted.

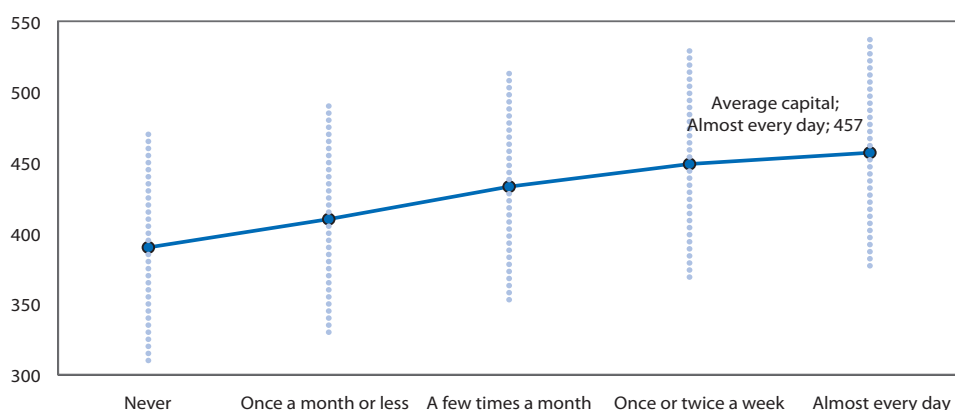
Lessons for educational policy: is ICT enough?

The analysis has shown that computer use increases student performance but that this increase is not the same for all students. Students with high capital benefit more from an increase in computer use than students with low capital. This finding has two interesting policy implications. First, as the benefits from computer use depend on the characteristics of each student, policies to increase ICT use need to be tailored to students. This means that policy makers should try to identify the relevant personal and socio-economic characteristics. The analysis presented in this chapter provides a tool for targeting students.

Second, the positive effects of computer use on student performance are greatest when they are supported by a sufficient level of capital. Skills,

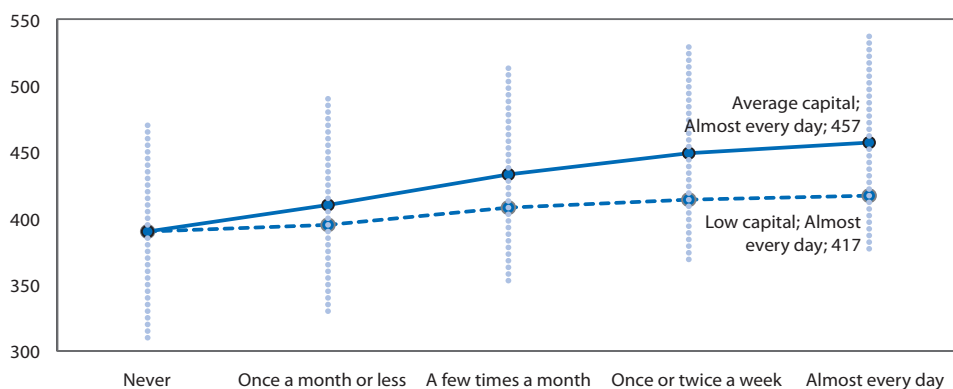
interests and attitudes affect students' engagement with ICT, the activities they carry out on the computer and how well. An increase in ICT use that is not supported by an increase in capital would have a lower impact on student performance. Figure 4.7 illustrates this point. If a student increases his/her computer use from “never” to “almost every day” and if this increase is accompanied by an increase of his/her capital, His/her performance will increase along the straight line. If the same student increased his/her computer use from “never” to “almost every day” but his/her level of capital remained unchanged, he/she would move along the dotted line, which is always below the straight one.

Figure 4.6. Increase in science scores due to computer use: average



StatLink  <http://dx.doi.org/10.1787/812404467647>

Figure 4.7. Increase in science scores due to computer use: average and differential



StatLink  <http://dx.doi.org/10.1787/812414257675>

This finding implies that a policy to increase computer use among disadvantaged students will be fully effective only if it is accompanied by other policies to increase their capital, improve their complementary skills, raise their interest and change their attitudes.

Conclusions and implications

The analysis of the relation between ICT use and science scores in PISA 2006 reinforces the main findings of PISA 2003 and other studies regarding ICT use and performance and reveals a complex, non-linear relation. The results show the need for more micro-studies that explore the kinds of computer usage that are most effective for subject-based learning as measured in PISA and other surveys, as well as how they relate to other mediating variables, such as individual, family and school characteristics.

The analysis also confirmed once again the strong influence of the home, notably in the relation between home computer use and performance in PISA science scores. Although it is not possible to talk about causality, the findings suggest that schools are not always able to compensate for what students experience and learn at home. This calls for stronger links between school-work and what students do at home, in particular with respect to students' use of ICT for entertainment and school activities. This is particularly important in order to better support low achievers.

The apparently negative association between performance and some kinds of computer usage, shown by PISA 2003 and now PISA 2006, carries a warning not to assume that more is better for students' performance. On the one hand, it suggests that it is the quality, rather than the quantity, of ICT usage that determines the contribution that these technologies make to students' academic performance. On the other hand, it suggests that school subject knowledge assessments such as PISA may not capture the full effect of ICT use in learning and that new assessments should be developed and implemented to measure what have been called 21st century skills. These are cross-disciplinary skills, many of them directly related to the use of ICT or what has been called ICT literacy. Many projects have explored these new instruments, and many countries have started to use them at a national level. But to date, there has been no international large-scale ICT-based assessment to measure 21st century skills. Moreover, the micro-econometric analysis also revealed that the effect of ICT use is not the same for all students. A combination of economic, cultural and social factors seems to play an important role in determining the set of competences, skills and attitudes that students may require to achieve the full benefits of ICT use.

Key findings

- The key finding for mathematics scores in PISA 2003 were confirmed for science scores in PISA 2006.
- Students' experience with using computers is positively related to their PISA 2006 science scores. Those with less than a year's experience typically perform only the simplest science tasks. On average they score more or less one proficiency level below those with more than five years of experience using computers. These differences decrease but remain important when controlling for students' socio-economic background.
- Frequency of computer use at home is more clearly correlated with PISA 2006 science scores than with frequency of computer use at school. In every country, students reporting rare or no use of computers at home score lower than their counterparts reporting frequent use. However, students using computers most frequently at school do not perform better than others in all countries.
- Students with higher levels of computer use for a range of purposes do not always have better PISA 2006 science scores. Students with a medium level of computer use most often had the best results.
- Students with high confidence in their ability to undertake Internet tasks or to use the computer to perform high-level tasks performed better in science in PISA 2006 than did less confident students.
- The educational benefits young people can obtain from computer use may vary according to their economic, cultural and social capital which helps them to acquire the necessary set of competences, skills and attitudes.

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Chapter 5

Conclusions and policy recommendations

PISA 2006 data have unveiled a number of interesting messages in terms of ICT accessibility and use by 15-year-old students. This chapter summaries the main findings and draws out some important policy recommendations particularly regarding how education can cope with the emerging second digital divide, the importance of ICT in the development of 21st century skills and, finally, the need for monitoring progress over time, particularly through dedicated indicators of educational uses of ICT.

Conclusions

Today all students in OECD countries are familiar with computers

On the whole, less than 1% of 15-year-old students in OECD countries declared that they had never used a computer. In the light of progress since 2000, this may no longer be the case even for that small percentage. Interestingly, neither gender nor socio-economic status is an important determinant in this respect.

Although familiarity with computers has increased rapidly, not all students present the same level in terms of length or intensity of ICT use. In a number of OECD countries, the majority of students have at least five years of experience with computer use; and in all PISA countries, the majority of students have at least three years of experience.

Frequency of use at home is not paralleled by use at school

Most 15-year-old students use their computers frequently at home but not in school. In most OECD countries more than 80% use computers frequently at home but a majority do not use them at school, except in Hungary. Since 2003, the increase has been similar in both home and school use, but the difference remains significant.

Despite increasing investment in ICT infrastructure in schools, student-computer ratios are still a handicap for ICT use in schools

The OECD average is five students per computer. It has dropped by 50% since 2000, when it was ten students per computer, but it is roughly the same as it was in 2003. This might suggest that there have been no significant investments in computer equipment between 2003 and 2006, but old computers may have been replaced by new ones. In this case, it would be a positive development. However, data regarding expenditure on technology in education are lacking.

Digital media are increasingly used as educational resources, but disparities across countries are large

As access to digital media at home increases, the importance of books as tools for coursework decreases. Interestingly, this seems to favour the Internet rather than educational software. In most countries, educational software is the least frequent resource used at home.

The main use of computers is related to the Internet or to entertainment

More than 60% of students frequently use their computers for e-mail or chatting (69%) and to look up information about people, things or ideas on the Internet (61%). More than 50% frequently use them to download music (58%) and play games (54%), and the relatively lowest percentage of frequent computer use is to download software (41%) and to collaborate with a group or team (37%). Compared to PISA 2003, 15-year-old students' use of all types of use classified here as Internet and entertainment has increased the most.

A variety of student profiles are linked to different uses of technology

Although both gender and socio-economic status are closely linked to particular uses of computers, student profiles introduce a more nuanced picture. These profiles reflect certain types of use of ICT, either for education or entertainment. They take into account not only a student's gender or socio-economic status but also individual characteristics such as self-confidence in doing computer-based activities and performance in the PISA science test.

The six suggested profiles (*analogue*, *digi-casual*, *digi-wired*, *digi-sporadic*, *digi-educational*, and *digi-zapper*) reflect a variety of computer uses which relate to socio-economic status (ESCS) and gender. They also appear to be linked to performance in science. They suggest that in place of the common dichotomy of “male gamer” and “female communicator”, males and females are better identified with these more multifaceted profiles of users of digital media.

The strong socio-economic differences in students' use of computers for leisure activities is not matched by similar differences in the type of activities more likely to be practiced in school. In fact, the difference between students from the bottom and top ESCS quarters is twice as large for Internet and entertainment uses as it is for programmes and software uses. This is an important finding because it gives support to the assumption that school use of digital media can help to reduce the digital divide.

ICT familiarity matters for educational performance

Performance differences associated with the length of time students have been using a computer remain once socio-economic background is accounted for. Clearly, higher performers have more experience with computer use. The biggest differences are between students who have just started using computers (less than a year) and those who have used computers for at least one

year. Compared to students who have used a computer for less than a year and accounting for ESCS in OECD countries, there is, on average, a 30 score point advantage for students who have used computers for one to three years; a 51 score point advantage for students who have used computers for three to five years; and a 61 score point advantage for students who have used computers for more than five years. In fact, in Australia, Austria, Belgium, Iceland and Korea, accounting for socio-economic background, the performance differences between students who have used a computer for more than five years and students who have used a computer for less than one year are equivalent to one proficiency level or more on the PISA science scale.

There is a stronger correlation between educational performance and frequency of computer use at home than at school

In a large majority of countries, the benefits of greater computer use tend to be larger at home than at school. Therefore, despite the better environment and support that schools are expected to provide, the use of computer tends to have less impact at school than at home, although the differences are statistically significant only in some countries. In Canada, Finland, Germany, Iceland, Japan, Poland, Portugal and Spain and in the partner country Croatia, computer use at home has a significantly greater effect for almost all frequencies of use. In Belgium, Greece and Italy and in partner countries Bulgaria and Serbia, the difference in favour of home is significant only at high frequencies of computer use.

In every country, students reporting “rare” or “no use” of computers at home score lower than their counterparts who report frequent use. In all OECD countries except Turkey, students using computers frequently at home perform at level 3 on the science proficiency scale. In the majority of OECD countries, students rarely or never using computers at home perform at level 2, except in Canada, Finland, Japan, Korea and Sweden, where they perform at level 3, but always below frequent computer users. With respect to moderate users at home their performance on the science proficiency scale is lower than that of frequent users in the majority of countries and higher than that of rare or non-users; they perform at the mid-lower end of level 3 and mid-higher end of level 2.

For frequency of use at school, the association with performance is less clear. In the majority of OECD countries, students with different frequencies of use perform very similarly in the PISA science test. In fact, on average in OECD countries, moderate and rare or non-users score the same and frequent users slightly lower. However, in Finland, Germany, Greece, Italy, Japan, Korea, New Zealand, Spain and Turkey, more frequent computer users perform less well than less frequent users. Also, in Belgium, Canada, Iceland, Netherlands, Norway, Sweden and Switzerland, moderate users perform better than frequent and rare or non-users.

Clearly, in the case of school use, more computer use does not mean better results in subject-based standardised tests such as PISA 2006. This observation is consistent with findings in previous studies which show that larger amounts of computer use are not always associated with better academic performance.

With the right skills and background, more frequent computer use can lead to better performance

The analysis of PISA data shows that for educational performance, computer use amplifies a student's academic skills and competences. These competences are closely related to the student's background, and particularly to his/her economic, cultural and social capital.

If a student – because of family, peer group or school – has a good stock of cultural and social capital, he/she can benefit from computer use in a way that increases educational performance. Given the lack of such capital, the benefits from more computer use would be limited.

Skills, interests and attitudes affect students' engagement with technology. An increase in computer use either at home or at school that is not supported by higher cultural and social capital will have less impact on student performance. This makes the issue of the digital divide particularly critical in education.

The first digital divide has faded in schools but a second one is emerging

In all OECD countries except Mexico, all students attend schools equipped with computers, 88% of which are connected to the Internet. In Mexico, 2% of students do not attend equipped schools.

There is almost no correlation between students' socio-economic background and never using a computer at school or with what their schools' principal reports as the proportion of computers available for instruction or connected to the Internet. These results indicate that the digital divide is not an issue at schools.

On average, 87% of students have access to a computer at home. In most OECD countries this is the case for at least three-quarters of students. The exceptions are Greece (74%), Japan (63%), Mexico (42%) and Turkey (38%). Seventy-six percent of students have access to the Internet at home; in 20 OECD countries this is the case for at least three-quarters of all students. The increase since 2003 is noteworthy: access to a computer at home has increased by 7 percentage points and access to the Internet by 12 points.

However, there is still a digital gap related to home access. The socio-economic background of students still plays a strong role, especially for digital educational resources. However, the differences are decreasing in OECD countries, owing to the sharp increase in access among students in the bottom quarter. The percentage difference between students in the top and bottom quarters of the PISA index of ESCS, in terms of how likely they are to have computers at home, is still 25%, a large figure even though it has improved from 36% in 2003.

In the light of the results of this study, it can be concluded that the importance of the digital divide in education goes beyond the issue of access to technology. A second form of digital divide has been identified between those who have the necessary competences and skills to benefit from computer use and those who do not. These competences and skills are closely linked to students' economic, cultural and social capital. This has important implications for policy and practice.

Policy recommendations

Among the policy implications of this report, some are related to the need to increase awareness of the consequences and opportunities of technology-rich learning environments or the need for co-ordinated and holistic policies. Moreover, there are operational implications regarding changes needed in the classroom. The following presents these policy implications in more detail.

Raise awareness among educators, parents and policy makers of the consequences of increasing ICT familiarity

In OECD countries students are quite familiar with computers and are increasingly becoming heavy users of digital media. As the OECD project on the New Millennium Learners¹ shows, this is likely to have important implications in areas such as cognitive skills development, social values and attitudes, and learning expectations.

Educators and policy makers have to address the important social, cultural and economic changes that ICT implies for young people, often without the necessary adult assistance and participation. When addressing this issue, it is important to discard simplifications and stereotypes and recognise that students use technology in a variety of way.

Policy makers have to consider the educational implications of the changes brought about by technology. First, students need technology and access to digital media for learning purposes which current provision in schools may not adequately meet. More importantly, education standards need to include the kind of skills and competences that can help students become responsible and

performing users of technology and to develop the new competences required in today's economy and society which are enhanced by technology, in particular those related to knowledge management.

Teachers need a clear policy message in this respect: public recognition that teachers are expected to deal with these competences as a priority in their subject areas or domains. This public recognition will require the inclusion of these competences in national and international assessments. In a number of respects, those responsible for teaching the new millennium learners have to be able to guide them in their educational journey through digital media. Teacher training,² both initial and in-service, is crucial for disseminating this key message and for equipping teachers with the required competences.

Parents also need to be aware of these changes. In the light of the findings of this study, it is clear that parents have a crucial responsibility to help their children develop a responsible attitude to using digital media in a networked environment. Their influence has to go beyond safety issues to include approaching digital media critically to make the most of them. Public policies can help to raise parental awareness in this respect.

Identify and foster the development of 21st century skills and competences.

Social and economic developments require equipping young people with new skills and competences that will allow them to benefit from emerging forms of socialisation and to contribute actively to economic development under a system in which knowledge is the main asset. These skills and competences are often referred to as 21st century skills and competences, to indicate their relation to the needs of emerging models of economic and social development rather than those of the past century, which were better suited to an industrial mode of production.

Young people are already experiencing the new forms of socialisation and social capital acquisition that ICT developments are contributing to create. Their education, both at school and at home, must provide them with the social values and attitudes and with the constructive experiences that will allow them to use these opportunities responsibly so as to contribute to these new spaces of social life and benefit from new windows for informal learning.

Today's labour force needs the skills and competences that are required by a knowledge economy. Most of these are related to knowledge management and include processes related to selection, acquisition, integration, analysis and sharing of knowledge in socially networked environments. Not surprisingly, most of these competences, if not all, are either supported or enhanced by ICT. For young people, schools are the only place where such competences and skills can be gained.

Accordingly, governments should make an effort to identify and conceptualise the required set of skills and competences so as to incorporate them into the educational standards that every student should be able to meet by the end of compulsory schooling. Two requirements must be fulfilled. First, participation of both economic and social institutions, ranging from companies to higher education institutions, is critical. Second, this set of skills and competences must become the core of what teachers and schools care about. This will only be achieved by incorporating them into national education standards that are enforced and assessed by governments.

Address the second digital divide

Among young people in OECD countries, the first digital divide seems to be disappearing: access to ICT is no longer an issue. However, a second and more subtle digital divide is emerging, which is related to the educational benefits young people obtain from computer use depending on their economic, cultural and social capital. According to the results of this study, computer use can make a difference in educational performance if the student has the appropriate set of competences, skills and attitudes. Without these, no matter how intense the student's use of a computer, the expected benefits will not be realised. Therefore, computer use, and perhaps use of digital media use in general, tends to enhance the positive influence of a student's cultural and social capital and add significant gains in terms of educational performance.

This is another powerful reason for governments to engage in the identification of the 21st century skills and competences, and for teachers and schools to consider the importance of developing them in order to address this second digital divide. Teachers and schools can make a difference for students who lack the cultural and social capital that will allow them to benefit from the use of digital media in a way that is significant for their educational performance. If teachers and schools fail to acknowledge this second digital divide, and act accordingly, they will reinforce its emergence.

It is important to realise that the fact that students appear to be technologically “savvy” does not mean that they have developed the skills and competences that will make them responsible, critical and creative users of technology. The fact that educators – parents and particularly teachers – are less familiar with the technology than young people should not be an excuse to relinquish their educational responsibility for developing these 21st century skills and competences.

Adopt holistic policy approaches to ICT in education

While the availability of computers and Internet connections at schools is clearly a prerequisite for ICT use, it is a necessary but not a sufficient condition. The availability of educational software and other digital learning resources and the ICT competences of teachers are equally important in ensuring broader and more efficient use of ICT in the teaching and learning processes, both at school and at home. Further investments in relevant policies could enhance the development of new ICT-based pedagogies that would lead to wider application in the educational sector of technologies that students increasingly and widely use at home mainly for recreational purposes. These three investment policies are closely interconnected among themselves and with ICT use. Higher levels of ICT use could lead to more demand for more and better quality digital content and higher levels of teachers' ICT competences, potentially creating a virtuous circle.

Certainly, besides public investments, other factors could improve ICT use in schools. An overall favourable environment, the inclusion of ICT in curriculum design or strong leadership and commitment from teachers and headmasters to implement ICT-rich teaching could also significantly influence the use of ICT in schools.

Perhaps, as the PISA 2006 data partially show, one of the limitations of many educational ICT policies is that most countries have not developed holistic policies for the educational use of ICT. The current results suggest the value of critically evaluating current policies and their results in order to develop complementary policies that would maximise the effects of the deployed infrastructure.

Adapt school learning environments as computer ratios improve and digital learning resources increase

In their traditional form, schools are not the best learning environment for developing the competences required by today's society and economy. Developing these competences will require a particular learning environment which offers easy access to digital media. Students should be able to locate and use a computer at any time, according to the particular needs of their individual and team assignments.

Although there are indications of innovative developments in this direction everywhere, governments should provide the conditions for them to flourish and should assess their effects. Two areas which deserve particular public policy attention are computer ratios and the availability of digital learning resources.

Benefitting from recent technology and market developments, a number of countries have begun to experiment with one-to-one computing (one computer per student). Although it is too early to say whether the results of these experiences justify the one-to-one principle, it is increasingly clear that today's average ratio of students per computer (five in 2006 as in 2003) is not good enough to provide substantial opportunities for computer use in schools. Governments need to explore the opportunities offered by new technology and market opportunities and make an effort to invest in low-cost computers when replacing desktop machines. This alone could result in better ratios and availability of computers for student use, as low-cost computers are mostly laptops.

Availability of digital learning resources should be the second priority for the development of these new learning environments. Nordic countries in particular³ have addressed this issue with a variety of government-led initiatives by textbook producers and public broadcasting companies and, more recently, by support for bottom-up initiatives created by communities of user-producer teachers.

Promote greater computer use at school and experimental research on its effects

PISA 2006 data unveiled a number of interesting messages in terms of ICT accessibility and use by 15-year-old students. They show that while there is an increasingly better ICT infrastructure in schools in terms of computers and Internet access, its use remains weak, especially compared to home ICT use. Although this finding cannot be generalised to all participating countries, and differences across countries are significant, it indicates that ICT use is not simply the result of the available infrastructure, where most public investments in ICT in education have focused until now. This opens a debate about the type of policies that should be encouraged to foster ICT use in schools.

One of the most striking findings of this study, and of previous ones as well, is that even accounting for a student's socio-economic status, there is a significant correlation between computer use at home and educational performance, a correlation that does not appear for computer use at school. Some analysts have rightly pointed out that in a school setting what matters is the use of the computer in the wider context of a particular educational strategy. According to this view, gains in educational performance would only appear in the presence of a successful educational strategy. Therefore, the amount of use, *i.e.* the time a computer is used, would not matter at all. This certainly makes sense from a strictly educational perspective, but fails to explain why substantial gains in educational performance are correlated with the frequency of computer use at home. This is even more striking in view of the mostly leisure or entertainment-oriented nature of computer activities performed by students at home.

An alternative explanation for the lack of correlation between computer use at school and educational performance is that frequency of use is currently irrelevant. There are positive gains from computer use at home because the frequency of use has reached a critical level. According to the existing evidence, such a level is far from the marginal one a student currently experiences at school.

Clearly, increased frequency of computer use at schools cannot be achieved simply by governmental regulations. Use will increase only with the implication of teachers and schools' commitment to develop 21st century skills and competences and efforts to remove the second digital divide. As said, this will be facilitated by recent technology and market developments which, even in a context of economic crisis, can provide a window of opportunity.

Governments should therefore make an effort to convey the message that computer use matters for the education of young people and do their best to engage teachers and schools in raising the frequency of computer use to a level that becomes relevant. This would constitute a clear indication of teachers' and schools' engagement with the development of 21st century skills and competences, but it would also be expected to lead to gains in educational performance.

Governments need to create the necessary incentives. As responsible professionals teachers are particularly receptive to one powerful incentive: the evidence of what works. Until now research in the field of ICT in education has not been able to develop an evidence base from which teachers can obtain clear guidelines for improved practice. This is at least partly because of the scattered qualitative case-based research that seems to have dominated the field. It is in the best interests of the uptake of computer and digital media at schools that governments invest in large-scale experimental research and panel studies, as a few OECD countries are already doing.

The pending agenda

Data availability remains one of the main handicaps for understanding the role of ICT in education. New data could give a more nuanced picture of the availability and use of ICT and its effects on educational attainment, the quality of the teaching and learning process, and the development of the 21st century competences.

Many of these new data could be developed using the PISA ICT familiarity questionnaire, amending some current questions or introducing some new ones. In particular, more precise data would be needed on ICT use as the current questionnaire allows for potentially large disparities in certain

categories. For example, “almost every day” could mean students who use ICT 15 minutes a day or those who use it 5 hours a day. In addition, questions related to the types of ICT use should be modified to measure more accurately 21st century competences, such as editing, revising, writing, working on spreadsheets or preparing presentations rather than simply familiarity with basic IT tasks. Equally, the questionnaire could introduce some new dimensions in current questions, *e.g.* use of digital learning resources for schoolwork both at home and in school, classified by subject. This would provide important data for understanding the development and effects of policies aiming at expanding the available digital content.

The use of the questionnaire could guarantee the representativeness of the sample as well as the comparability of the results across countries and their link with educational performance.

Indicators are needed on ICT uptake and use in education. Although PISA studies will remain one of the most important sources of evidence in this area, knowledge economies and societies would greatly benefit from a set of indicators that would monitor progress in ICT uptake and give important information about use, ranging from issues such as frequency to purpose and effects. If carried out in an internationally comparable framework, such as the one OECD provides for indicators in education, they can become an important tool for benchmarking policies and practices across countries.

In addition to PISA studies and indicators of ICT in education, a third source of evidence would be required to overcome the constraint imposed by the fact that most current information comes from declarations (students, teachers and head teachers) rather than from direct observation. As argued above, large-scale experimental research and panel studies can make an important contribution to enlarge the evidence base on ICT in education.

Finally, the new data should be analysed in order to understand better the determinants and effects of ICT use in school and at home and the effect of ICT use on educational performance, the development of 21st century skills and competences, and the improvement of the quality of the teaching and learning process. This would make it possible to develop better informed policies and thus enhance the potential effectiveness and efficiency of policy design and increase public accountability.

Notes

1. See *www.oecd.org/edu/nml*.
2. The OECD is currently developing a comparative study on the use of technology in initial teacher training. See *www.oecd.org/edu/nml/itt*.
3. As in the OECD study on Digital Learning Resources as Systemic Innovation in the Nordic Countries. See *www.oecd.org/edu/systemicinnovation/dlr*.

Annex A

Supplementary tables

Table A.1. Students who have never used a computer

Participating countries	% all students		Increase/decrease from PISA 2003 to PISA 2006	PISA 2003		PISA 2006	
	PISA 2003	PISA 2006		% males	% females	% males	% females
Australia	0.15	0.53	0.38	0.03	0.27	0.76	0.29
Austria	0.09	0.17	0.08	0.04	0.14	0.31	0.03
Belgium	0.53	0.39	-0.14	0.44	0.61	0.51	0.26
Canada	0.47	0.42	-0.05	0.20	0.76	0.65	0.18
Chile		0.95				1.06	0.83
Czech Republic	0.23	0.57	0.34	0.31	0.15	0.75	0.33
Denmark	0.05	0.28	0.23	0.03	0.07	0.47	0.10
Finland	0	0.07	0.07			0.08	0.06
Germany	0.2	0.53	0.33	0.32	0.08	0.82	0.23
Greece	1.96	3.16	1.2	2.53	1.35	3.22	3.10
Hungary	0.11	0.62	0.51	0.14	0.09	0.82	0.39
Iceland	0.06	0.66	0.6	0.00	0.12	1.23	0.10
Ireland	0.29	1.33	1.04	0.27	0.30	1.66	1.02
Italy	1.83	1.68	-0.15	2.10	1.54	1.70	1.66
Japan	1.44	2.38	0.94	1.01	1.89	2.58	2.16
Korea	0.11	0.25	0.14	0.03	0.16	0.38	0.12
Mexico	13.12			13.79	12.36		
Netherlands		0.44				0.50	0.38
New Zealand	0.25	0.59	0.34	0.30	0.21	0.82	0.38
Norway		1.04				1.22	0.85
Poland	0.52	0.43	-0.09	0.37	0.67	0.41	0.44
Portugal	0.58	0.71	0.13	0.57	0.59	0.55	0.86
Slovak Republic	3.82	1.42	-2.4	0.13	0.27	1.63	1.19
Spain		2.17				2.96	1.36
Sweden	0.2	0.52	0.32			0.88	0.13
Switzerland	0.34	0.4	0.06	0.31	0.37	0.61	0.18
Turkey	14.43	6.61	-7.82	21.04	9.06	4.07	9.68
United States				1.46	2.57		
OECD average	1.71	1.09	-0.62	2.17	1.60	1.18	1.02

Table A.1. Students who have never used a computer *(continued)*

Participating countries	% all students		Increase/decrease from PISA 2003 to PISA 2006	PISA 2003		PISA 2006	
	PISA 2003	PISA 2006		% males	% females	% males	% females
Partner countries							
Bulgaria		3.9				4.57	3.18
Colombia		2.96				3.07	2.87
Croatia		1.44				1.15	1.74
Jordan		3.53				5.16	1.98
Latvia	0.59	0.83	0.24	0.71	0.47	1.00	0.67
Liechtenstein	0.3	0.62	0.32	0.00	0.59	1.35	0.00
Lithuania		0.69				0.80	0.58
Macao, China		0.78				0.95	0.60
Qatar		5.13				6.25	4.08
Russian Federation	6.19	6.04	-0.15	7.15	5.23	5.79	6.27
Serbia	1.39	4.27	2.88	1.29	1.50	3.78	4.77
Slovenia		0.45				0.72	0.18
Thailand	5.83	0.3	-5.53	5.86	5.79	0.36	0.26
Uruguay	3.89	1.95	-1.94	4.40	3.34	2.25	1.67

Table A.2. **Percentage of students with access to a computer to use for schoolwork and a link to the Internet at home, PISA 2003 and PISA 2006**

Results based on students' self-reports

	A computer you can use for schoolwork		A link to the Internet	
	PISA 2003	PISA 2006	PISA 2003	PISA 2006
Australia	94.0	96.3	84.6	91.9
Austria	93.0	95.7	69.4	80.0
Belgium	87.2	93.4	74.8	89.1
Canada	93.3	96.3	88.8	94.0
Chile		54.3		30.2
Czech Republic	76.7	86.8	49.1	66.4
Denmark	93.3	98.3	83.4	95.7
Finland	87.9	95.3	76.7	92.6
France	78.6	86.1	55.9	73.0
Germany	91.0	95.4	73.5	87.5
Greece	52.8	74.0	35.3	53.4
Hungary	67.6	85.3	26.0	50.7
Iceland	96.8	98.1	92.3	97.7
Ireland	79.9	87.9	66.2	80.5
Italy	78.0	89.4	62.4	72.2
Japan	46.2	62.5	60.5	74.9
Korea	95.1	97.2	93.1	96.5
Luxembourg	90.1	93.2	75.4	86.7
Mexico	33.2	42.0	18.4	23.3
Netherlands	95.9	97.4	89.0	96.5
New Zealand	87.3	93.3	82.1	89.4
Norway	93.6	96.8	87.6	95.6
Poland	60.3	79.6	34.2	51.3
Portugal	74.7	86.1	47.5	58.1
Slovak Republic	57.1	77.1	17.4	40.2
Spain	79.0	88.1	49.8	65.8
Sweden	94.9	97.8	89.6	96.7
Switzerland	86.6	96.0	79.1	93.4
Turkey	23.3	38.2	14.4	24.6

Table A.2. **Percentage of students with access to a computer to use for schoolwork and a link to the Internet at home, PISA 2003 and PISA 2006** (*continued*)

	A computer you can use for schoolwork		A link to the Internet	
	PISA 2003	PISA 2006	PISA 2003	PISA 2006
United Kingdom	91.4	95.2	80.7	90.4
United States	87.5	88.8	81.8	85.1
OECD	78.9	86.9	64.6	76.4
Argentina		48.6		29.9
Azerbaijan		15.7		13.0
Brazil	27.2	36.0	23.3	38.8
Bulgaria		65.8		59.0
Chinese Taipei		89.2		91.8
Colombia		31.0		15.6
Croatia		84.1		71.1
Estonia		82.9		80.7
Hong Kong, China	92.7	97.0	88.4	96.9
Indonesia	7.9	14.4	2.6	4.3
Israel		90.0		84.1
Jordan		59.2		29.7
Kyrgyzstan		12.1		7.1
Latvia	44.0	72.6	16.3	52.3
Liechtenstein	94.2	95.5	81.2	96.4
Lithuania		80.1		56.7
Macao, China	89.4	94.7	67.0	89.4
Montenegro		59.9		54.3
Qatar		87.7		81.3
Romania		61.0		32.1
Russian Federation	29.1	58.7	13.9	34.4
Serbia	38.4	72.3	25.9	51.6
Slovenia		96.8		85.9
Thailand	26.3	40.6	18.7	23.3
Tunisia	20.0	32.3	10.7	20.2
Uruguay	45.6	56.7	35.6	40.3

Table A.3. Percentage of students with access to various ICT and educational resources at home, by national top and bottom quarters of the index of economic, social and cultural status (ESCS)

	A computer you can use for schoolwork		Educational software		Books to help with your schoolwork	
	Bottom quarter	Top quarter	Bottom quarter	Top quarter	Bottom quarter	Top quarter
Australia	89.9	99.6	89.9	99.6	72.7	95.6
Austria	89.6	98.8	89.6	98.8	69.0	93.4
Belgium	83.5	98.9	83.5	98.9	74.5	94.5
Canada	89.9	99.8	89.9	99.8	66.6	92.5
Chile	15.3	90.7	15.3	90.7	83.6	96.9
Czech Republic	65.6	99.0	65.6	99.0	86.5	98.7
Denmark	95.4	99.9	95.4	99.9	75.4	96.8
Finland	88.8	99.2	88.8	99.2	76.8	95.8
France	65.9	97.8	65.9	97.8	79.8	96.8
Germany	88.9	99.2	88.9	99.2	84.7	97.8
Greece	46.9	91.8	46.9	91.8	68.9	87.7
Hungary	60.1	98.7	60.1	98.7	81.0	99.4
Iceland	96.3	99.5	96.3	99.5	85.9	99.5
Ireland	71.8	96.7	71.8	96.7	78.8	96.0
Italy	74.7	97.8	74.7	97.8	88.5	97.7
Japan	36.6	78.3	36.6	78.3	77.0	95.5
Korea	92.4	99.6	92.4	99.6	62.0	94.8
Luxembourg	84.3	98.6	84.3	98.6	83.2	96.2
Mexico	5.2	85.1	5.2	85.1	59.9	92.4
Netherlands	94.4	99.2	94.4	99.2	42.0	84.8
New Zealand	81.9	99.4	81.9	99.4	76.1	96.5
Norway	91.9	99.9	91.9	99.9	78.1	99.6
Poland	45.7	98.0	45.7	98.0	91.3	99.6
Portugal	63.9	98.9	63.9	98.9	80.0	96.5
Slovak Republic	45.6	94.6	45.6	94.6	77.9	98.7
Spain	71.8	97.3	71.8	97.3	81.2	94.3
Sweden	94.2	99.9	94.2	99.9	68.3	97.5
Switzerland	92.0	98.5	92.0	98.5	71.9	93.5
Turkey	7.7	77.2	7.7	77.2	68.2	97.0

Table A.3. Percentage of students with access to various ICT and educational resources at home, by national top and bottom quarters of the index of economic, social and cultural status (ESCS) (continued)

	A computer you can use for schoolwork		Educational software		Books to help with your schoolwork	
	Bottom quarter	Top quarter	Bottom quarter	Top quarter	Bottom quarter	Top quarter
United Kingdom	86.4	99.8	86.4	99.8	84.2	98.2
United States	69.5	99.5	69.5	99.5	68.1	93.8
OECD	72.4	96.7	72.4	96.7	75.3	95.7
Argentina	14.5	88.7	14.5	88.7	76.7	94.1
Azerbaijan	3.4	41.5	3.4	41.5	49.8	88.5
Brazil	5.9	75.6	5.9	75.6	80.2	95.3
Bulgaria	22.9	95.5	22.9	95.5	65.0	95.3
Chinese Taipei	79.8	95.2	79.8	95.2	50.4	91.6
Colombia	4.3	71.3	4.3	71.3	72.0	97.1
Croatia	62.3	96.0	62.3	96.0	86.8	96.5
Estonia	64.8	93.7	64.8	93.7	78.3	97.9
Hong Kong, China	92.7	98.9	92.7	98.9	56.4	95.3
Indonesia	0.5	46.1	0.5	46.1	76.7	96.0
Israel	77.2	99.4	77.2	99.4	75.6	95.9
Jordan	24.1	88.2	24.1	88.2	45.3	79.4
Kyrgyzstan	4.5	29.6	4.5	29.6	82.7	95.3
Latvia	37.5	93.5	37.5	93.5	90.1	98.8
Liechtenstein	98.8	98.8	98.8	98.8	75.9	89.3
Lithuania	52.2	98.1	52.2	98.1	81.5	97.8
Macao, China	88.0	98.9	88.0	98.9	59.4	88.2
Montenegro	23.3	91.4	23.3	91.4	34.9	80.3
Qatar	72.4	97.7	72.4	97.7	60.7	93.6
Romania	20.8	92.5	20.8	92.5	78.6	98.3
Russian Federation	24.6	90.0	24.6	90.0	87.3	97.8
Serbia	39.2	95.5	39.2	95.5	85.8	97.7
Slovenia	91.2	99.4	91.2	99.4	91.0	98.6
Thailand	8.2	85.9	8.2	85.9	67.1	88.8
Tunisia	2.6	80.8	2.6	80.8	49.1	92.3
Uruguay	22.4	90.3	22.4	90.3	86.0	96.9

Table A.4. **Correlation between students' ESCS and ICT resources at school**Table A.4a. **Correlation between students' ESCS and never having used a computer at school (OECD countries)**

OECD countries	Correlation	Correlation standard error
Australia	-0.07	0.01
Austria	-0.04	0.02
Belgium	-0.09	0.02
Canada	-0.06	0.01
Chile	0.25	0.02
Czech Republic	-0.10	0.02
Denmark	-0.06	0.01
Finland	0.00	0.02
Germany	0.00	0.02
Greece	0.18	0.02
Hungary	0.03	0.02
Iceland	-0.07	0.02
Ireland	0.01	0.02
Italy	0.01	0.02
Japan	0.02	0.03
Korea	0.05	0.03
Netherlands	-0.03	0.03
New Zealand	-0.02	0.02
Norway	-0.05	0.02
Poland	-0.01	0.02
Portugal	-0.02	0.02
Slovak Republic	-0.03	0.02
Spain	0.00	0.02
Sweden	-0.06	0.02
Switzerland	-0.03	0.02
Turkey	0.15	0.04
OECD	-0.01	0.02

Table A.4b. Correlation between students' ESCS and schools principals' reports about:

OECD countries	Proportion of computers available for instruction		Proportion of computers connected to the Internet/WWW	
	Correlation	SE	Correlation	SE
Australia	-0.02	0.04	0.00	0.04
Austria	-0.06	0.05	-0.02	0.04
Belgium	-0.02	0.04	0.13	0.03
Canada	-0.06	0.03	0.01	0.03
Czech Republic	-0.02	0.04	0.10	0.03
Denmark	0.01	0.03	0.04	0.03
Finland	-0.06	0.04	0.04	0.02
Germany	-0.08	0.04	0.02	0.04
Greece	-0.15	0.09	0.01	0.04
Hungary	-0.03	0.05	0.16	0.03
Iceland	0.07	0.02	0.09	0.01
Ireland	-0.01	0.04	0.02	0.03
Italy	-0.09	0.03	0.08	0.03
Japan	-0.17	0.03	0.01	0.04
Korea	-0.15	0.04	0.00	0.05
Luxembourg	0.10	0.01	0.00	0.01
Mexico	-0.02	0.04	0.35	0.04
Netherlands	-0.11	0.04	-0.01	0.04
New Zealand	-0.07	0.03	0.04	0.03
Norway	-0.02	0.03	0.00	0.03
Poland	-0.10	0.04	0.06	0.03
Portugal	0.02	0.04	0.03	0.05
Slovak Republic	-0.08	0.05	0.03	0.04
Spain	0.04	0.03	-0.10	0.05
Sweden	0.00	0.03	0.03	0.03
Switzerland	-0.08	0.02	0.06	0.02
Turkey	-0.02	0.05	0.06	0.05
United Kingdom	-0.02	0.03	0.03	0.04
United States	0.03	0.04	0.09	0.05
OECD	-0.04	0.04	0.05	0.04

Table A.5. **Computers per student by school location**

	Computers per student by school location		
	Rural locations or towns	Cities	Difference
Australia	0.30	0.33	-0.03
Austria	0.32	0.19	0.13
Belgium	0.18	0.14	0.04
Canada	0.25	0.22	0.03
Chile	0.05	0.06	-0.01
Czech Republic	0.15	0.16	-0.01
Denmark	0.22	0.17	0.05
Finland	0.18	0.18	0.00
Germany	0.11	0.09	0.02
Greece	0.11	0.10	0.00
Hungary	0.22	0.23	0.00
Iceland	0.21	0.23	-0.02
Ireland	0.12	0.12	0.00
Italy	0.15	0.13	0.03
Japan	0.33	0.24	0.09
Korea	0.38	0.24	0.14
Luxembourg	0.21	0.79	-0.57
Mexico	0.08	0.11	-0.04
Netherlands	0.19	0.18	0.01
New Zealand	0.26	0.26	0.00
Norway	0.31	0.27	0.04
Poland	0.09	0.07	0.02
Portugal	0.10	0.10	0.00
Slovak Republic	0.08	0.10	-0.02
Spain	0.13	0.12	0.01
Sweden	0.17	0.17	0.00
Switzerland	0.21	0.19	0.02
Turkey	0.08	0.05	0.03
United Kingdom	0.33	0.38	-0.05
United States	0.31	0.25	0.06
OECD	0.20	0.20	0.00

Table A.5. **Computers per student by school location** (*continued*)

	Computers per student by school location		
	Rural locations or towns	Cities	Difference
Argentina	0.05	0.05	0.00
Azerbaijan	0.01	0.02	-0.01
Brazil	0.02	0.04	-0.02
Bulgaria	0.06	0.06	0.00
Chinese Taipei	0.20	0.19	0.02
Colombia	0.21	0.14	0.07
Croatia	0.07	0.08	0.00
Estonia	0.11	0.09	0.01
Indonesia	0.03	0.07	-0.04
Israel	0.10	0.13	-0.02
Jordan	0.05	0.06	0.00
Kyrgyzstan	0.01	0.03	-0.02
Latvia	0.09	0.06	0.03
Liechtenstein	0.30		
Lithuania	0.08	0.06	0.03
Macao, China	0.16	0.16	0.00
Montenegro	0.04	0.03	0.01
Qatar	0.17	0.15	0.02
Romania	0.08	0.07	0.01
Russian Federation	0.04	0.06	-0.02
Serbia	0.06	0.06	0.00
Slovenia	0.21	0.14	0.07
Thailand	0.10	0.11	-0.01
Tunisia	0.02	0.02	-0.01
Uruguay	0.07	0.06	0.01

Table A.6. Correlation of percentage of various types of computers in school with ESCS

	PISA 2006							
	Proportion of computers available for instruction		Proportion of computers connected to Internet/WWW		Ratio of computers to school size		Ratio of computers for instruction to school size	
	Correlation	SE	Correlation	SE	Correlation	SE	Correlation	SE
Australia	-0.02	0.04	0.00	0.04	0.15	0.03	-0.02	0.01
Austria	-0.06	0.05	-0.02	0.04	-0.02	0.02	0.02	0.04
Belgium	-0.02	0.04	0.13	0.03	-0.02	0.03	0.00	0.03
Canada	-0.06	0.03	0.01	0.03	-0.08	0.02	-0.07	0.02
Czech Republic	-0.02	0.04	0.10	0.03	0.03	0.03	0.03	0.03
Denmark	0.01	0.03	0.04	0.03	0.03	0.03	0.03	0.03
Finland	-0.06	0.04	0.04	0.02	0.03	0.02	0.03	0.02
Germany	-0.08	0.04	0.02	0.04	0.02	0.05	0.04	0.05
Greece	-0.15	0.09	0.01	0.04	0.10	0.04	0.08	0.05
Hungary	-0.03	0.05	0.16	0.03	-0.01	0.06	-0.01	0.06
Iceland	0.07	0.02	0.09	0.01	-0.02	0.02	0.01	0.01
Ireland	-0.01	0.04	0.02	0.03	0.02	0.02	-0.04	0.04
Italy	-0.09	0.03	0.08	0.03	-0.01	0.03	-0.01	0.03
Japan	-0.17	0.03	0.01	0.04	-0.20	0.03	-0.07	0.03
Korea	-0.15	0.04	0.00	0.05	-0.26	0.07	0.03	0.05
Luxembourg	0.10	0.01	0.00	0.01	0.15	0.01	0.16	0.01
Mexico	-0.02	0.04	0.35	0.04	0.03	0.04	0.02	0.04
Netherlands	-0.11	0.04	-0.01	0.04	-0.02	0.04	-0.02	0.04
New Zealand	-0.07	0.03	0.04	0.03	-0.06	0.02	-0.05	0.02
Norway	-0.02	0.03	0.00	0.03	0.01	0.03	0.01	0.03
Poland	-0.10	0.04	0.06	0.03	0.01	0.01	-0.02	0.02
Portugal	0.02	0.04	0.03	0.05	0.04	0.02	0.04	0.02
Slovak Republic	-0.08	0.05	0.03	0.04	0.12	0.06	0.12	0.06
Spain	0.04	0.03	-0.10	0.05	0.01	0.01	0.01	0.01
Sweden	0.00	0.03	0.03	0.03	-0.03	0.02	-0.02	0.02
Switzerland	-0.08	0.02	0.06	0.02	-0.01	0.03	0.01	0.03
Turkey	-0.02	0.05	0.06	0.05	-0.05	0.05	-0.05	0.05
United Kingdom	-0.02	0.03	0.03	0.04	-0.06	0.02	-0.07	0.02
United States	0.03	0.04	0.09	0.05	-0.02	0.05	-0.02	0.05
OECD	-0.04	0.04	0.05	0.04	0.00	0.04	0.01	0.04

Table A.7. Percentage of students in schools whose principals report that instruction is hindered by a shortage of computers for instruction

	PISA 2006	PISA 2003	PISA 2000
	%	%	%
Australia	33.9	34.1	29.5
Austria	24.4	36.4	41.0
Belgium	41.9	43.5	18.3
Canada	38.0	45.4	30.4
Chile	49.7		46.9
Czech Republic	38.8	43.0	37.2
Denmark	38.7	46.3	27.4
Finland	37.0	38.9	42.7
France			28.2
Germany	27.4	33.8	50.1
Greece	23.7	48.7	70.2
Hungary	15.0	26.7	11.8
Iceland	24.2	33.7	44.8
Ireland	54.9	49.5	41.4
Italy	21.4	29.0	31.7
Japan	19.5	39.0	31.3
Korea	32.0	10.2	22.1
Luxembourg	42.0	23.4	23.0
Mexico	59.2	60.2	68.9
Netherlands	38.8	37.8	38.9
New Zealand	41.6	42.2	40.4
Norway	45.8	73.7	60.6
Poland	33.1	55.2	38.4
Portugal	52.2	54.8	38.5
Slovak Republic	38.9	67.5	
Spain	43.3	58.0	29.3
Sweden	46.4	50.2	50.5
Switzerland	15.7	20.6	22.5
Turkey	61.3	81.7	
United Kingdom	37.1	46.4	55.6

Table A.7. **Percentage of students in schools whose principals report that instruction is hindered by a shortage of computers for instruction** (*continued*)

	PISA 2006	PISA 2003	PISA 2000
	%	%	%
United States	33.3	26.4	26.3
OECD	36.5	43.3	37.5
Argentina	51.3		54.0
Azerbaijan	80.7		
Brazil	76.5	66.9	63.0
Bulgaria	48.1		57.2
Chinese Taipei	16.7		
Colombia	69.7		
Croatia	46.2		
Estonia	44.1		
Hong Kong, China	23.3	27.5	15.1
Indonesia	59.4	47.8	57.9
Israel	36.6		28.0
Jordan	67.1		
Kyrgyzstan	90.4		
Latvia	48.6	52.1	39.5
Liechtenstein		11.8	41.2
Lithuania	50.7		
Macao, China	20.8	49.4	
Montenegro	78.7		
Qatar	42.9		
Romania	59.5		
Russian Federation	79.8	77.4	86.4
Serbia	57.6	78.0	
Slovenia	21.0		
Thailand	44.5	63.1	62.3
Tunisia	78.2	68.0	
Uruguay	60.1	70.4	

Table A.8. **Differences in percentages of students with frequent computer use at home and at school, PISA 2003 and PISA 2006**

OECD countries	PISA 2006	PISA 2006	PISA 2003	PISA 2003	Diff PISA 2006-	Diff PISA 2006-
	Home frequent use (%)	School frequent use (%)	Home frequent use (%)	School frequent use (%)	PISA 2003 Home frequent use (%)	PISA 2003 School frequent use (%)
Australia	94	73	87	59	7	14
Austria	89	73	81	53	8	20
Belgium	93	55	84	27	9	28
Canada	94	47	90	40	4	7
Czech Republic	85	69	70	41	15	28
Denmark	95	65	84	68	11	-3
Finland	93	51	78	36	15	15
Germany	90	31	82	23	8	8
Greece	72	58	57	45	15	13
Hungary	84	85	67	80	17	5
Iceland	97	53	89	41	8	12
Ireland	77	47	61	24	16	23
Italy	85	50	76	51	9	-1
Japan	52	50	37	26	15	24
Korea	93	36	86	28	7	8
Netherlands	97	65				
New Zealand	87	50	79	43	8	7
Norway	96	54				
Poland	81	61	59	44	22	17
Portugal	87	60	78	34	9	26
Slovak Republic	77	65	65	42	12	23
Spain	86	42				
Sweden	96	47	89	48	7	-1
Switzerland	93	43	81	30	12	13
Turkey	53	53	48	46	5	7
OECD	86	55	74	44	12	11

Table A.9. **Index of ICT Internet and entertainment use**

Gender difference (males-females)	
	Gender difference (M-F)
Sweden	0.71
Norway	0.69
Turkey	0.64
Lithuania	0.63
Poland	0.62
Liechtenstein	0.60
Czech Republic	0.59
Denmark	0.58
Iceland	0.57
Finland	0.56
Slovenia	0.55
Greece	0.54
Latvia	0.54
Germany	0.53
Bulgaria	0.49
Russian Federation	0.49
Italy	0.48
Portugal	0.47
OECD average	0.47
Switzerland	0.46
Slovak Republic	0.45
Netherlands	0.45
Croatia	0.45
Belgium	0.44
Jordan	0.43
Spain	0.43
Uruguay	0.42
Serbia	0.41
Canada	0.40
Hungary	0.37
Australia	0.36
Austria	0.36
Chile	0.35
Korea	0.34
New Zealand	0.31
Colombia	0.28
Macao. China	0.27
Qatar	0.24
Ireland	0.20
Thailand	0.16
Japan	0.13

Table A.10. Difference in science by years of experience using computers after accounting for the socio-economic background of students

Performance on science scale, by using computer									Observed difference in science						Difference in science after accounting for the socio-economic background of students								
Less than one year	One to three years			Three to five years			More than five years			One to three years	Three to five years			More than five years			One to three years	Three to five years			More than five years		
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Diff		S.E.	Diff	S.E.	Diff	S.E.	Diff		S.E.	Diff	S.E.	Diff	S.E.	
Australia	426	11.16	451	6.74	505	3.39	537	2.15	25	12.55	79	11.48	111	11.18	11	11.63	54	11.10	73	10.67			
Austria	404	13.68	473	9.88	507	4.10	527	3.58	69	12.10	103	13.21	124	13.22	49	11.52	77	11.29	89	11.13			
Belgium	432	10.05	464	4.66	507	2.74	540	2.10	32	10.13	76	9.43	108	9.79	24	10.25	55	9.58	73	9.78			
Canada	478	9.98	488	5.81	523	3.01	544	1.84	10	11.32	45	9.91	66	9.79	17	10.51	41	9.35	51	9.10			
Chile	385	3.68	421	4.16	452	4.40	478	4.79	36	3.96	66	5.18	93	5.74	30	3.88	48	5.01	50	5.87			
Czech Republic	435	8.40	472	5.32	509	4.01	536	4.08	37	8.56	74	9.12	101	8.74	29	8.84	52	9.20	66	8.92			
Denmark	421	14.69	461	6.83	483	4.32	506	3.02	41	15.75	62	14.56	86	14.59	30	13.89	45	13.31	56	13.84			
Finland	487	10.90	535	4.87	551	2.85	574	2.23	49	12.67	65	10.82	88	10.76	38	13.24	52	11.56	66	11.18			
Germany	444	10.04	490	6.19	522	3.53	537	4.09	46	10.42	78	9.86	93	9.45	32	10.84	55	9.87	57	9.16			
Greece	426	5.18	465	3.32	489	3.80	502	3.63	40	4.53	64	5.17	76	5.36	29	4.30	44	4.95	44	5.35			
Hungary	437	8.32	481	3.60	506	3.21	522	2.95	44	8.16	69	8.78	85	8.38	33	7.56	47	8.06	46	7.79			
Iceland	399	21.11	449	5.37	480	3.19	506	2.00	51	21.20	81	21.23	107	21.42	44	21.30	71	21.26	89	21.65			
Ireland	443	7.44	484	4.52	508	3.97	529	2.87	41	7.51	65	7.93	86	7.57	34	7.01	51	7.28	62	6.81			
Italy	414	4.69	449	2.74	480	2.40	501	2.27	35	4.87	66	4.83	87	4.92	28	5.27	52	4.88	65	5.11			
Japan	486	5.79	520	4.20	548	3.72	560	3.50	34	5.79	62	5.60	75	6.04	26	5.68	49	5.49	57	5.73			
Korea	417	15.22	463	10.14	500	5.05	530	3.35	46	14.61	83	14.64	113	14.95	43	13.11	72	12.97	90	13.01			

Table A.10. Difference in science by years of experience using computers after accounting for the socio-economic background of students (continued)

Performance on science scale, by using computer										Observed difference in science						Difference in science after accounting for the socio-economic background of students					
Less than one year	One to three years		Three to five years		More than five years								One to three years		Three to five years		More than five years				
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Diff	S.E.	Diff	S.E.	Diff	S.E.	Diff	S.E.	Diff	S.E.	Diff	S.E.	
Netherlands	484	23.66	483	9.35	514	4.75	538	2.80	-1	24.22	30	23.50	54	23.15	5	23.71	32	22.69	44	22.62	
New Zealand	423	9.96	453	7.84	511	3.54	549	2.52	30	11.95	88	10.16	126	9.52	27	12.01	64	9.72	85	9.49	
Norway	435	12.30	458	6.82	476	3.65	499	2.61	23	13.31	42	12.53	65	12.40	27	13.98	38	13.28	52	13.21	
Poland	436	4.43	475	3.65	497	2.89	520	2.69	39	4.83	61	4.88	84	4.99	31	5.02	46	4.64	47	5.57	
Portugal	393	7.15	435	3.73	472	2.82	498	3.28	42	6.94	79	6.56	105	6.97	38	6.62	65	6.34	70	6.69	
Slovak Republic	432	5.01	475	3.69	497	3.05	518	3.80	43	5.20	65	5.36	86	6.31	29	4.64	40	4.93	42	5.39	
Spain	423	5.50	458	3.53	491	2.44	516	2.74	35	6.11	68	5.38	93	5.68	28	6.02	53	5.38	67	5.40	
Sweden	439	23.33	480	6.80	499	3.86	510	2.61	41	24.25	59	23.02	71	23.24	31	22.77	43	21.28	48	21.29	
Switzerland	424	8.15	480	4.83	512	3.68	527	3.19	56	7.93	88	7.66	103	8.02	45	8.35	67	7.76	73	8.56	
Turkey	400	3.26	421	4.47	433	4.88	451	7.37	21	4.46	33	5.24	51	7.73	13	4.14	18	4.38	14	4.52	
OECD	433	12.01	471	6.04	501	3.70	523	3.34	37	12.42	67	11.98	90	12.03	30	12.06	51	11.50	61	11.52	
Bulgaria	385	5.99	424	6.10	464	6.08	480	7.13	40	6.40	80	6.92	95	8.27	24	5.60	48	5.42	46	6.15	
Colombia	354	6.36	377	4.25	398	3.55	418	3.61	23	5.99	44	7.30	64	6.75	20	5.93	38	7.44	45	6.90	
Croatia	437	4.61	475	3.23	500	3.00	522	3.03	38	4.78	63	5.11	86	5.17	33	4.73	49	5.02	59	5.42	
Jordan	378	3.99	416	3.06	439	3.02	453	3.80	38	4.28	61	4.56	75	5.09	35	4.25	52	4.46	46	4.68	

Table A.10. Difference in science by years of experience using computers after accounting for the socio-economic background of students (*continued*)

Performance on science scale, by using computer									Observed difference in science						Difference in science after accounting for the socio-economic background of students					
Less than one year	One to three years			Three to five years			More than five years			One to three years	Three to five years	More than five years	One to three years	Three to five years	More than five years					
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Diff							S.E.	Diff	S.E.	Diff	S.E.
Latvia	445	5.36	478	3.80	495	3.63	509	3.78	32	5.95	50	6.31	64	6.03	28	5.90	41	6.29	44	6.71
Liechtenstein	450	39.60	462	22.51	516	7.65	536	6.52	12	45.18	66	39.86	86	40.01	70	42.05	98	30.79	106	30.50
Lithuania	435	4.02	480	3.53	504	3.30	515	4.44	45	4.73	69	5.13	80	5.50	30	4.88	44	5.58	38	5.87
Macao, China	457	7.78	484	3.64	510	2.15	526	1.60	28	8.67	54	8.16	69	7.95	28	8.60	52	8.21	63	8.23
Qatar	318	1.80	335	1.98	361	2.66	382	1.80	17	2.83	43	3.03	64	2.78	18	2.86	44	3.03	60	3.15
Russian Federation	455	4.30	482	4.71	507	4.58	506	4.85	27	5.30	53	4.85	51	5.49	21	5.65	41	4.74	29	6.11
Serbia	397	3.62	430	3.67	454	3.36	472	3.85	33	4.21	57	3.58	75	4.49	26	4.23	42	3.76	42	5.05
Slovenia	453	8.96	493	4.08	518	3.53	536	1.97	40	10.22	66	10.52	83	9.02	28	9.78	34	10.55	40	8.99
Thailand	381	4.75	396	2.73	423	2.63	449	3.39	15	5.01	42	5.10	68	5.51	13	4.56	32	4.62	33	4.56
Uruguay	375	4.49	410	3.88	437	4.13	470	2.98	35	4.14	62	4.86	95	4.72	31	4.06	47	5.15	54	5.29

Table A.11. Frequency of computer use at home and at school and student performance on PISA science scale

	Frequency of computer use at school						Frequency of computer use at home					
	Frequent use			Moderate use			Frequent use			Moderate use		
	%	S.E.		%	S.E.		%	S.E.		%	S.E.	
OECD countries												
Australia	533	(2.4)	530	(3.2)	509	(4.4)	534	(2.3)	483	(6.0)	462	(5.9)
Austria	516	(4.4)	516	(5.7)	508	(6.8)	518	(3.9)	493	(6.5)	460	(8.2)
Belgium	522	(2.5)	524	(4.4)	513	(4.5)	522	(2.2)	475	(7.9)	454	(9.1)
Canada	538	(2.2)	542	(2.5)	535	(3.1)	541	(1.9)	527	(6.1)	486	(5.4)
Czech Republic	526	(3.9)	507	(5.2)	484	(6.2)	526	(3.4)	496	(10.9)	457	(6.3)
Denmark	499	(3.5)	499	(4.2)	480	(6.0)	499	(3.1)	487	(8.8)	448	(10.1)
Finland	561	(2.8)	570	(2.9)	566	(3.6)	566	(2.1)	571	(9.2)	534	(5.9)
Germany	512	(4.7)	524	(5.4)	535	(3.9)	528	(3.5)	505	(6.1)	468	(8.6)
Greece	462	(3.9)	476	(6.9)	502	(3.4)	484	(3.3)	479	(6.9)	452	(3.9)
Hungary	506	(2.7)	485	(6.0)	516	(8.5)	514	(2.7)	484	(9.1)	463	(3.9)
Iceland	495	(2.4)	501	(3.6)	483	(3.1)	494	(1.7)	468	(10.9)	439	(15.5)
Ireland	516	(3.5)	501	(6.8)	515	(3.5)	521	(3.3)	506	(5.0)	481	(4.7)
Italy	469	(2.4)	487	(2.9)	489	(4.0)	484	(2.0)	474	(4.6)	434	(4.7)
Japan	533	(4.3)	542	(6.1)	543	(5.2)	553	(3.6)	537	(4.5)	513	(4.1)
Korea	510	(6.3)	525	(6.2)	531	(3.6)	523	(3.3)	533	(7.8)	502	(10.5)
Netherlands	527	(3.7)	544	(3.9)	523	(7.7)	532	(2.9)	460	(14.2)	480	(15.3)
New Zealand	526	(3.2)	543	(3.9)	547	(3.6)	542	(2.4)	507	(8.5)	480	(6.9)
Norway	488	(3.3)	500	(3.2)	484	(5.2)	493	(2.6)	463	(11.7)	436	(9.7)
Poland	503	(3.0)	497	(3.7)	500	(3.5)	509	(2.5)	479	(8.9)	468	(3.5)
Portugal	478	(3.6)	469	(4.2)	481	(4.3)	486	(2.6)	448	(8.2)	421	(5.2)
Slovak Republic	498	(3.5)	480	(5.0)	486	(4.8)	505	(2.9)	491	(6.8)	451	(4.5)

Table A.11. Frequency of computer use at home and at school and student performance on PISA science scale
(continued)

	Frequency of computer use at school						Frequency of computer use at home					
	Frequent use %	S.E.	Moderate use %	S.E.	Rare or no use %	S.E.	Frequent use %	S.E.	Moderate use %	S.E.	Rare or no use %	S.E.
Spain	490	(2.8)	495	(4.2)	499	(3.4)	500	(2.5)	473	(6.3)	445	(3.8)
Sweden	503	(3.2)	512	(3.2)	504	(4.2)	506	(2.4)	498	(10.5)	494	(14.2)
Switzerland	511	(3.9)	520	(3.5)	514	(3.6)	515	(3.2)	500	(8.4)	465	(7.8)
Turkey	416	(5.3)	423	(9.0)	448	(6.3)	446	(6.3)	413	(11.9)	419	(3.6)
OECD	506	(3.7)	508	(5.0)	508	(5.0)	514	(3.1)	490	(8.7)	465	(8.2)
Partner countries												
Bulgaria	450	(5.8)	433	(7.5)	419	(9.2)	462	(6.5)	389	(14.1)	406	(5.7)
Chile	434	(4.6)	458	(6.0)	449	(5.9)	467	(4.6)	428	(11.2)	415	(3.0)
Colombia	394	(3.5)	403	(5.3)	399	(10.1)	425	(3.7)	372	(10.9)	390	(3.3)
Croatia	500	(2.7)	504	(5.8)	495	(5.0)	506	(2.4)	477	(8.2)	456	(4.8)
Jordan	428	(2.8)	415	(5.8)	405	(6.4)	435	(3.3)	404	(8.9)	410	(2.7)
Latvia	495	(3.2)	476	(5.1)	483	(7.0)	502	(3.1)	466	(9.6)	468	(4.2)
Liechtenstein	504	(5.6)	542	(13.3)	555	(12.2)	526	(4.5)	473	(37.1)	477	(26.7)
Lithuania	492	(3.0)	491	(4.8)	489	(5.5)	501	(3.0)	455	(10.9)	451	(3.4)
Macao-China	514	(1.3)	510	(5.3)	495	(4.8)	514	(1.1)	484	(5.9)	485	(7.1)
Qatar	353	(1.0)	353	(3.5)	354	(2.5)	356	(1.0)	340	(4.4)	326	(3.3)
Russian Federation	487	(3.7)	481	(8.4)	473	(6.3)	492	(3.9)	450	(11.9)	471	(4.5)
Serbia	441	(3.0)	436	(5.6)	410	(8.8)	449	(3.0)	425	(7.5)	409	(4.5)
Slovenia	531	(1.5)	528	(3.9)	487	(4.3)	523	(1.2)	516	(10.5)	474	(8.7)
Thailand	423	(2.4)	416	(4.9)	414	(5.7)	456	(3.2)	425	(12.2)	402	(2.2)
Uruguay	429	(4.9)	449	(5.0)	447	(3.1)	459	(3.3)	430	(10.2)	414	(3.6)

Annex B

Methodological approach to categorising student profiles

Three options that were not included in the original categorisation are explored here:

1. Moving “browsing the Internet” from “leisure use” to “educational use”;
2. Testing the impact of frequency by using two categories (e.g. “high use” and “low use”) instead of three categories, which would make it more difficult to be included in the category “high use” than in that of “frequent use” (as in the original categorisation);
3. Testing the impact of using two indices developed in PISA 2006:
 - i. “Index of ICT internet/entertainment use” (p. 344), consisting of activities covered by the leisure use index and one other activity: “use the Internet to collaborate with a group or team”, and
 - ii. “Index of ICT programme/software use” (p. 344), consisting of educational use activities and two other activities: “drawing, painting or using graphics programmes” and “writing computer programmes”.

First, two of the options above were combined in one analysis in which “browse the Internet” was moved to “educational use” and two categories of ICT use were used (“high” and “low”). The details of this analysis and the results are described in Annex C. Also, a set of new profiles based on the indexation of ICT-use developed in PISA 2006 was explored.

These complementary analyses including additional options made it possible to test and validate the original indexation. The additional analyses supported the patterns emerging from the original categorisation (leisure use and educational use). The original categories were kept, although the new analyses indicated a rather similar set of profiles, for several reasons:

- Originally, browsing the Internet was part of leisure use. However, it might as well be considered a central part of educational use of ICT and benefit from being placed within educational use. Nevertheless, a factor analysis showed that browsing the Internet was more closely connected to leisure use than to educational use, so the original categorisation was maintained.
- Originally three-category solution was used (“frequent”, “monthly” and “rare”). A two-category solution was considered (“high” and “low”), but it provides less nuanced as well as less transparent profiles (“low” is broad and not very consistent).
- In the original categorisation the indices made by PISA 2006 were not used for two reasons. First, the PISA 2006 indices included three questions, which were not supported by the factor analysis previously referred to. Second, based on conceptual judgments, these questions did not fit into the original categories (leisure use and educational use).

Finally, the profiles were developed as questions defining “leisure use”, and the questions defining “educational use” were recorded by collapsing answers. “Frequent” is defined as ≥ 3 and ≤ 4 (mean score on the composite indices, *e.g.* the span from those who answered “almost every day” on each question to those who answered “once or twice a week” on each question), “Monthly” is defined as > 2 and < 3 (“a few times a month”), and “Rare” is ≤ 2 (those who answer “once a month or less” and below).

All analysis is run by SPSS. A final student weight [W_FSTUWT]) and repeated measures (as described in the PISA SPSS Manual) were used in all analyses, apart from developing a composite index for educational use and a composite index for leisure use. Replication methods are used when calculating average scores on different indices within the profiles.

Annex C

Econometric model and methodological approach to the analysis of the effects of technology on student performance

Econometric model

The aim is to assess whether computer use at home (IT^*) has an impact on science scores (*Science*) after having controlled for other observable student characteristics (X):

$$Science_i = \beta' X_i + \delta(IT_i^*) + e_i \quad (1)$$

where the subscript $i = 1, \dots, N$ indicate the students, X denotes observable individual characteristics; e is an individual idiosyncratic error term which influences the student's science scores; β denotes unknown parameters; and δ is an unknown function which generates higher science scores through additional computer use.

Actual computer use IT^* is not observed but only the variable IT (computer use frequency) with discrete values: 1 (never), 2 (once a month or less), 3 (a few times a month), 4 (once or twice a week) and 5 (almost every day). This means:

$$IT_i = 1 \text{ if } IT_i^* < \mu_1; IT_i = 2 \text{ if } \mu_1 < IT_i^*; IT_i = 3 \text{ if } \mu_2 < IT_i^* \leq \mu_3;$$

$$IT_i = 4 \text{ if } \mu_3 < IT_i^* \leq \mu_4; IT_i = 5 \text{ if } \mu_4 < IT_i^*.$$

The observable computer use frequency can be written as the following j dummy variables based on these discrete values:

$$D_{ij} = 1 \text{ if } IT_i = j \text{ and}$$

$$D_{ij} = 0 \text{ otherwise.}$$

Therefore, equation (1) can be estimated through the following empirical model which comprises the reduced form representations of the student's science score and computer use:

$$Science_i = \beta' X_i + \sum_{j=1}^s \delta_j D_{ij} + e_i, \quad i = 1 \dots N \quad (2)$$

$$IT_i^* = \lambda' Z_i + v_i, \quad i = 1 \dots N \quad (3)$$

$$IT_i = h(IT_i^*), \quad i = 1 \dots N \quad (4)$$

where X_i and Z_i continue to denote vectors of exogenous characteristics, possibly overlapping; e_i and v_i are jointly normally distributed error terms with zero means, variances σ_e^2 and σ_v^2 and covariance σ_{ev} ; β , δ and λ are vectors of parameters and the effects of computer use are captured by the δ s. The observed value of IT_i is obtained from the latent variable IT_i^* through the censoring function h in (4) which maps ranges of IT_i^* into ordinal discrete values represented by IT_i .

The primary difficulty in consistently estimating the parameters from (2) is the endogeneity of the computer use dummy variables. This is due to the potential for students to choose their frequency of computer use (*self-selection*). In general, therefore, $\sigma_{ev} \neq 0$, which implies that computer use choice is not weakly exogenous to the science score. This endogeneity is allowed for by employing the procedures of Vella and Gregory (1996).

Rewrite (2) conditioning on the observed value of IT_i and Z_i :

$$E(Science_i | IT_i, Z_i) = \beta' X_i + E(e_i | IT_i, Z_i) \quad (5)$$

Employing the assumption of joint normality, (5) becomes:

$$E(Science_i | IT_i, Z_i) = \beta' X_i + \theta E(v_i | IT_i, Z_i) \quad (6)$$

where θ is equal to σ_{ev}/σ_v .

Equation (6) can be estimated by least squares once there is an estimate of the conditional error $E(v_i | IT_i, Z_i)$. This is obtained in the following manner.

First, estimate the parameters from (3) and (4) by ordered probit. $E(v_i | IT_i, Z_i)$ is then computed as the value of the first derivative for each observation of the ordered probit likelihood function with respect to the intercept at the maximum likelihood estimates. This conditional error term from the computer use is a type of within sample prediction error. Accordingly, it can be interpreted as a measure of computer overuse or underuse. Note that it also accounts for the selection bias induced by estimating the β s over the various computer use frequency.

The coefficient θ captures the return or penalty to computer overuse. It reflects the covariance between the unobserved factors that affect science scores and the unobserved factors that affect computer use. Accordingly, it captures the process by which individuals self-select into computer use groups.

Computer use by location

Whether computer use has different effects at home and at school can be tested by rewriting equation (2) as follows:

$$Science_i = \beta' X_i + \sum_{j=1}^s \delta_j^h D_{ij}^h + \sum_{j=1}^s \delta_j^s D_{ij}^s + \sum_{j=1}^s \delta_j D_{ij} + e_i, i = 1 \dots N \text{ (2 bis)}$$

where s and h denote at school and at home, respectively, the D s are dummies for the frequency of computer use and the effects of computer use on science scores are captured by the δ s.

Ordered probit regression

The ordered probit regression of equations (3) and (4) is based on the hypothesis that actual computer use IT^* is normally distributed over $(-\infty; +\infty)$. This hypothesis, however, is not realistic since the normal distribution is symmetric whereas the distribution of IT tends to be skewed to the right, with a steep increase on the right and a long left tail. Moreover, with IT^* being normally distributed, negative frequency of computer use would become possible. To accommodate these features, equation (3) was transformed into (3'):

$$\ln(1/IT_i^*) = \lambda' Z_i + v_i \quad (3')$$

If $\ln(1/IT_i^*)$ is normally distributed, then the distribution of IT_i^* has the desired features (positive, skewed to the right).

PISA plausible values

For each test and each student, PISA reports five plausible values. None of these values is the actual score of a student but represents one of five random values drawn from the posterior distributions of the students' scores.¹ This implies that, in order to obtain unbiased estimates, the same regression model had to be run five times, once for each plausible value of the science scores, and the unbiased estimates and their standard computed based on these five sets of estimates. However, the estimates generated by the five regressions and their standard were almost identical. For the sake of simplicity, only the estimates for the first plausible value are reported.

PISA replicate weights

As many international educational surveys, PISA 2006 uses a two-stage sample design. As a result, sampling variances have to be estimated through replication methods. These methods function by generating several subsamples, or replicate samples, from the whole sample. The statistic of interest is

1. OECD (2005) PISA 2003 Data Analysis Manual: SPSS Users.

then estimated for each of these replicate samples and then compared to the whole sample estimate to provide an estimate of the sampling variance.

A replicate sample is formed simply through a transformation of the full sample weights according to an algorithm specific to the replication method. PISA 2006 uses the Fay's variant of the Balanced Repeated Replication with a Fay coefficient equal to 0.5 and 80 replicates. This means that each regression was run 81 times, first by weighting the data with the student final weight and then by weighting the data with each of the 80 replicates.

Reference

Vella, Francis and R.G. Gregory (1996), "Selection Bias and Human Capital Investment: Estimating the Rates of Return to Education for Young Males", *Labour Economics*, Vol. 3, No. 2, September 1996, pp. 197-219.

Annex D

PISA 2006 ICT familiarity questionnaire

The following questions ask about computers. This does not include calculators or games consoles like a <Sony PlayStation™>.

Q1 Is there a computer available for you to use at any of these places?

(Please <tick> one box on each row)

	<i>Yes</i>	<i>No</i>
a) At home.....	☐ ₁	☐ ₂
b) At school	☐ ₁	☐ ₂
c) At other places	☐ ₁	☐ ₂

Q2 Have you ever used a computer?

<i>Yes</i>	<i>No</i>
☐ ₁	☐ ₂

If you use a computer in any setting, please continue.

If you do not, please stop here. <Instructions>

Q3 How long have you been using computers?*(Please tick only one box)*

- Less than one year. ☐ 1
- One to three years. ☐ 2
- Three to five years. ☐ 3
- More than five years. ☐ 4

Q4 How often do you use a computer at these places?*(Please <tick> one box on each row)*

- | | <i>Almost
every day</i> | <i>A few
times each
week</i> | <i>Between
once a
week and
once a
month</i> | <i>Less than
once a
month</i> | <i>Never</i> |
|--------------------------|-----------------------------|--------------------------------------|---|---------------------------------------|----------------------------|
| a) At home..... | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 |
| b) At school | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 |
| c) At other places | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 |

Q5 How often do you use:*(Please <tick> one box on each row)*

	<i>Almost every day</i>	<i>A few times each week</i>	<i>Between once a week and once a month</i>	<i>Less than once a month</i>	<i>Never</i>
a) the Internet to look up information about people, things, or ideas?.....	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
b) games on a computer?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
c) Word processing (e.g. <Word ® or WordPerfect®>)?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
d) the Internet to collaborate with a group or team?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
e) spreadsheets (e.g. <Lotus 1 2 3 ® or Microsoft Excel®>)?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
f) the Internet to download software (including games)?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
g) drawing, painting or graphics programs on a computer?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
h) educational software such as Mathematics programs?.....	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
i) the computer to help you learn school material?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
j) the Internet to download music?.....	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
k) the computer for programming?.....	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
l) a computer for electronic communication (e.g. e-mail or “chat rooms”)?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

Q6 How well can you do each of these tasks on a computer?*(Please <tick> one box on each row)*

	<i>I can do this very well by myself.</i>	<i>I can do this with help from some- one.</i>	<i>I know what this means but I cannot do it.</i>	<i>I don't know what this means.</i>
a) Start a computer game.	☐ ₁	☐ ₂	☐ ₃	☐ ₄
b) Use software to find and get rid of computer viruses.	☐ ₁	☐ ₂	☐ ₃	☐ ₄
c) Open a file.	☐ ₁	☐ ₂	☐ ₃	☐ ₄
d) Create/edit a document.	☐ ₁	☐ ₂	☐ ₃	☐ ₄
e) Scroll a document up and down a screen.	☐ ₁	☐ ₂	☐ ₃	☐ ₄
f) Use a database to produce a list of addresses	☐ ₁	☐ ₂	☐ ₃	☐ ₄
g) Copy a file from a floppy disk.	☐ ₁	☐ ₂	☐ ₃	☐ ₄
h) Save a computer document or file.	☐ ₁	☐ ₂	☐ ₃	☐ ₄
i) Print a computer document or file.	☐ ₁	☐ ₂	☐ ₃	☐ ₄
j) Delete a computer document or file.	☐ ₁	☐ ₂	☐ ₃	☐ ₄
k) Move files from one place to another on a computer.	☐ ₁	☐ ₂	☐ ₃	☐ ₄

	<i>I can do this very well by myself.</i>	<i>I can do this with help from some- one.</i>	<i>I know what this means but I cannot do it.</i>	<i>I don't know what this means.</i>
l) Get on to the Internet.....	☐ ₁	☐ ₂	☐ ₃	☐ ₄
m) Copy or download files from the Internet.	☐ ₁	☐ ₂	☐ ₃	☐ ₄
n) Attach a file to an e-mail message.....	☐ ₁	☐ ₂	☐ ₃	☐ ₄
o) Create a computer program (e.g. in <Logo, Pascal, Basic>).	☐ ₁	☐ ₂	☐ ₃	☐ ₄
p) Use a spreadsheet to plot a graph.	☐ ₁	☐ ₂	☐ ₃	☐ ₄
q) Create a presentation (e.g. using <PowerPoint>).	☐ ₁	☐ ₂	☐ ₃	☐ ₄
r) Play computer games.	☐ ₁	☐ ₂	☐ ₃	☐ ₄
s) Download music from the Internet.	☐ ₁	☐ ₂	☐ ₃	☐ ₄
t) Create a multi-media presentation (with sound, pictures, video).	☐ ₁	☐ ₂	☐ ₃	☐ ₄
u) Draw pictures using a mouse.....	☐ ₁	☐ ₂	☐ ₃	☐ ₄
v) Write and send e-mails.	☐ ₁	☐ ₂	☐ ₃	☐ ₄
w) Construct a web page.....	☐ ₁	☐ ₂	☐ ₃	☐ ₄

Q7 Thinking about your experience with computers:**To what extent do you agree with the following statements?***(Please <tick> one box on each row)*

	<i>Strongly agree</i>	<i>Agree</i>	<i>Disagree</i>	<i>Strongly disagree</i>
a) It is very important to me to work with a computer.	☐ ₁	☐ ₂	☐ ₃	☐ ₄
b) I think playing or working with a computer is really fun.	☐ ₁	☐ ₂	☐ ₃	☐ ₄
c) I use a computer because I am very interested.	☐ ₁	☐ ₂	☐ ₃	☐ ₄
d) I lose track of time when I am working with the computer.	☐ ₁	☐ ₂	☐ ₃	☐ ₄

Q8 Who taught you most about how to use COMPUTERS?*(Please <tick> only one box)*My school..... ☐ 1My friends..... ☐ 2My family..... ☐ 3I taught myself. ☐ 4Others..... ☐ 5**Q9 Who taught you most about how to use the INTERNET?***(Please <tick> only one box)*I don't know how to use the Internet ☐ 1My school..... ☐ 2My friends..... ☐ 3My family..... ☐ 4I taught myself. ☐ 5Others..... ☐ 6

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Are the New Millennium Learners Making the Grade?

TECHNOLOGY USE AND EDUCATIONAL PERFORMANCE IN PISA

OECD countries have undertaken significant investments to enhance the role of technology in education. What are the results of these investments? Is technology investment in education fulfilling our expectations? PISA 2006 provides a wealth of comparative data to begin answering these questions, including evidence on the availability and use of technology and the actual benefits accruing from it.

One of the most striking findings of this study is that the digital divide in education goes beyond the issue of access to technology. A new second form of digital divide has been identified: the one existing between those who have the right competencies to benefit from computer use, and those who do not. These competencies and skills are closely linked to the economic, cultural and social capital of the student.

This finding has important implications for policy and practice. Governments should make an effort to clearly convey the message that computer use matters for the education of young people and do their best to engage teachers and schools in raising the frequency of computer use to a level that becomes relevant. If schools and teachers are really committed to the development of 21st century competencies, such an increase will happen naturally. And only in these circumstances will clear correlations between technology use and educational performance emerge.

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