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IS TECHNOLOGY USE RELATED TO EDUCATIONAL PERFORMANCE? EVIDENCE FROM PISA

Purpose of this document

This document presents the main findings and policy implications of the analysis of the relationships between technology use and educational performance in science as measured in PISA. Two issues make this work particularly relevant. First, the recognition of the impact that Information and Communication Technologies (ICT) are having on our economies and societies, which are increasingly demanding new skills and competencies intended to make students competitive workers and responsible citizens in a knowledge-based model of social and economic development. Second, the growing awareness that the younger generations of learners are so adept to ICT and digital media that their learning expectations and educational performance become influenced, and this is why the OECD often refers to this as the emergence of the New Millennium Learners. These two issues, the policy concern about how effectively ICT are used in schools and the need to know more about the technology-induced changes experienced by students, set the context for the analysis of the relationships between technology use and educational performance.

The full study is about to be published as an OECD report under the title ***Are the New Millennium Learners Making Their Grades? Technology Use and Educational Performance in PISA.***

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Key findings

Today all students in OECD countries are familiar with computers

On the whole, less than 1% of 15 year-old students in OECD countries declare not to have used a computer at all. In the light of the progression done since 2000 it may well be expected that this remaining 1% will have faded by now. Interestingly enough, neither gender nor socio-economic statuses are important determinants in this respect.

Although familiarity of use has increased very fast, not all students present the same level both 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 of computer use and in all PISA countries the majority of students have at least three years of experience.

Frequency of use at home is unparalleled by school use.

The majority of fifteen-year-old students use their computers at home frequently, but they do not do so in schools. In most OECD countries more than 80% of them are using computers frequently at home, while when it comes to school use the majority of students do not use them –with the exception of Hungary. The increase since 2003 has been equivalent both in home and school use, but the difference remains significant.

Despite increasing investments in ICT infrastructure in schools, ratios can be still regarded as a handicap for higher ICT use in schools.

School computer rations have not improved since 2003. The OECD average ratio of students per computer is 5. This ratio has dropped by 50% since 2000, when the ratio was 10 students per computer. However, it is roughly the same that it was in 2003. From this it could be inferred that no significant investments in computer equipment have been taking place between 2003 and 2006, but old computers may have been replaced by new ones and, if this is the case, this should be seen as an important investment with a positive development. Moreover, this raises the issue of the difficulties associated with the lack of data about expenditure on technology in education.

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

As access to digital media at home increases, the importance of books as tools for coursework decreases. Interestingly enough, this does not seem to favour educational software at all, but rather the Internet. In most countries educational software is the least frequent resource at home.

The prevalent use of computers is related either to the Internet or to entertainment.

More than 60% of students frequently use their computers for e-mail or chat rooms (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%). Comparing with PISA 2003, the average percentage of 15-year-old students' use in all the types of use classified here as Internet and entertainment have increased

There is a variety of student profiles regarding technology use.

Although taken in isolation both gender and socio-economic status are closely linked to particular uses of computers, it is important to introduce a more nuanced picture by identifying different student profiles. These profiles emerge from the particular use of ICT, either for educational or entertainment purposes. These take into account not only in relation to student's gender or socio-economic status but also to some of their individual characteristics such as self-confidence doing computer-based activities and performance in the PISA science test.

The set of six suggested profiles (*analogous, digi-casuals, digi-wired, digi-sporadics, digi-educationals,* and *digi-zappers*) shows that different students report different use of computers and this relates to their socio-economic status (ESCS) and gender. Moreover, their diversity in use and preferences appear to be connected to their academic performance in science. This analysis brings for example the often used dichotomized image of the "male gamer" and the "female communicator" to a much more multifaceted one, where males and females can be identified with much more diverse profiles of digital media users.

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

ICT familiarity matters for educational performance.

Performance differences associated with the length of time students have been using a computer hold once accounting for socio-economic background. Clearly, higher performers have a lengthier experience of computer use. 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 only been using a computer for less than a year and once accounting for ESCS, on average in OECD countries there is a 30 score points advantage for students who have used computers for one to three years, a 51 score points advantage for students who have used computers for 3 to 5 years and a 61 score points advantage for students who have used computers for more than 5 years. In fact, in some countries such as Australia, Austria, Belgium, Iceland, and Korea, once accounting for socio-economic background, the performance differences between students who have used a computer for more than 5 years and students who have used a computer for less than one year remains equivalent to one proficiency level or more in 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 from higher computer use tend to be larger at home than a school. Therefore, despite the better environment and support that schools are expected to provide, the use of computer tends to have a lower impact at school than at home. These differences, however, are statistical significant only in some countries. In Canada, Germany, Spain, Finland, Iceland, Japan, Poland, Portugal and Croatia the higher effect of computer use at home is significant for almost all frequency of use. In Belgium, Greece, Italy, Bulgaria and Serbia, the difference is 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 counterpart reporting frequent use. 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, Japan, Korea, Sweden and Canada where students rarely or never using computers at home perform also at Level 3 --but always below frequent computer users. With respect to moderate users at home, in the majority of the countries their performance in the science proficiency scale is lower than frequent users and higher than rare or non-users and perform at the mid- lower end of level 3 and mid-higher end of level 2.

When it comes to frequency of use at school, there is a less clear association with performance. 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 in this test, and frequent users slightly less. On the other hand, in several countries such as Finland, Germany, Greece, Italy, Japan, Korea, New Zealand, Spain and Turkey the trend is the opposite of that for computer frequency of use at school: that is, more frequent computer users perform worse than less frequent users. Also, in several countries, such as Belgium, Canada, Iceland, Netherlands, Norway, Sweden and Switzerland, moderate users perform better than frequent and rare or non-users

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

If the student has the right skills and background, an increase in the frequency of computer use can lead to better performance.

The analysis of PISA data shows that in relation to educational performance computer use acts as an amplifier of the student's academic skills and competences. These competences are closely related to the student's background, and in particular to the economic, cultural and social capital.

If the student, either because of his family, peer group or school, has a good wealth of cultural and social capital, this will enable the student to benefit from computer use in a way that increases the educational performance. In the lack of such a capital, more computer use does not lead necessarily to better performance.

Skills, interests and attitudes affect the engagement of students with technology. An increase in computer use that is not supported by an increase in cultural and social capital, either at home or at school, would have a lower 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, all students attend schools equipped with computers. 88% of computers at schools are connected to the Internet. Mexico is the only exception to this, with 2% of students not attending equipped schools.

Importantly, there is almost no correlation between the socio-economic background of students and their never using a computer at school, or with what their schools' principals report in terms of proportion of computers at school 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 at least three fourths of students do. The only exceptions are Greece (74%), Japan (63%), Mexico (42%) and Turkey (38%). 76% of students have access to the Internet at home, with twenty OECD countries with at least three fourths of students with this resource at home. The increase since 2003 is quite noteworthy: access to a computer at home increase by 7 percentage points and access to the internet by 12.

However, there is still a digital gap regarding home access. The socio-economic background of students still plays a strong role, especially for those educational resources related to digital media, although the differences are decreasing over time in OECD countries thanks to the sharp increase in the access of students in the bottom quarter. The differences in percentages 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 25%. It is still an important 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 new second form of digital divide has been identified: the one existing between those who have the right competences and skills to benefit from computer use, and those who have not. These competences and skills are closely linked to the economic, cultural and social capital of the student. This has important implications for policy and practice.

Policy implications

There are important policy implications arising from the main findings of this report. Some of them are related to strategic aspects aiming at increasing awareness of the consequences and opportunities that technology rich learning environments can bring about or the need for coordinated and holistic policies. Moreover, there are also operational policy implications for changes needed in the classroom. The next lines present these policy implications in more detail.

To raise awareness among educators, parents and policy makers about the consequences of the increasing ICT familiarity

It is a fact that in OECD countries students are quite familiar with computers and are increasingly becoming heavy digital media users. As the OECD project on the New Millennium Learners[1] shows, this is likely to have important implications in areas such as cognitive skills development, social values and attitudes, and learning expectations.

Both educators and policy makers have to address this issue as an indication of an important social, cultural and economic change in which young people are taking part, often without the required adult assistance and participation. When addressing this issue, it is important to overcome simplifications and stereotypes and recognise that there is a variety of student profiles regarding how they use technology, how often and with which results.

Policy makers have to consider the implications of the changes brought by technology adept students. First, students have new needs in technology equipment and digital media access for learning purposes that may not be matched adequately with today's provision in schools. Second, more importantly, there is a need for a reappraisal of education standards as to include the kind of skills and competences that will help students to become responsible and performing users of technology, and also develop the range of new competences that today's economy and society require and that are enhanced by technology in particular those related to knowledge management.

1. More at www.oecd.org/edu/nml

Teachers need a clear policy message in this respect: a public recognition that teachers are expected to deal with these competences as a priority, in the context of the corresponding subject areas or domains they are responsible for. This public recognition will only emerge from the inclusion of these competences in national and international assessments. In a number of respects, those who have the responsibility to teach 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 the dissemination of this key message as well as to equip teachers with the required competences.

Parents do also need to be aware of how children are changing. In the light of the findings of this study it is clear that parents have a very crucial responsibility in helping their children to develop a responsible attitude to digital media use in a networked environment. Their influence has to go beyond safety issues as to incorporate the responsibility of approaching critically digital media and to make the most of them. Public policies can help to raise parental awareness in this respect.

To identify and foster the development of 21st Century skills and competences.

Developments in society and economy require education to equip young people with new skills and competences, which allow them to benefit from the emerging new forms of socialisation and to contribute actively to economic development under a system where the main asset is knowledge. These skills and competences are often referred to as the 21st Century skills and competences, as to indicate that they are more related to the needs of the emerging models of economic and social development than with those of the past Century, far more 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, needs to provide them with the social values and attitudes as well as with the constructive experiences that will allow them to benefit responsibly from these opportunities and contribute actively to these new spaces of social life and benefit from increased windows for informal learning.

On the other hand, today's labour force has to be equipped with the set of skills and competences which are suited to the knowledge economies. Most of them are related to knowledge management, which includes processes related to information selection, acquisition, integration, analysis and sharing 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 educated.

Accordingly, governments should make an effort to properly identify and conceptualise the set of skills and competences required as to incorporate them into the educational standards that every student should be able reach by the end of compulsory schooling. Governments should realise that to be successful in this process there are two requirements to be met. On the one hand, participation of both economic and social institutions, ranging from companies to higher education institutions, is critical. On the other hand, all this process risks of being irrelevant for schools unless this set of skills and competences becomes the very core of what teachers and schools should care about, and this can only be done by incorporating them into the national education standards that are enforced and assessed by governments.

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2. The OECD is currently developing a comparative study on the use of technology in initial teacher training. More at www.oecd.org/edu/nml/itt

To address the second digital divide.

In OECD countries the first digital divide among young people seems to be fading: access to ICT is not anymore a problem. However, a second and more subtle digital divide is emerging amongst them. This one is related to the educational benefits that young people can obtain from computer use according to 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 is duly equipped with the right set of competences, skills and attitudes. In their absence, no matter how intense the computer use is the expected benefits are going to be lost. Therefore, computer use, and it may well be hypothesised that digital media use at large as well, tend to multiply the positive influence of a student's cultural and social capital as to add significant gains in terms of educational performance.

This is yet 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 their development in the light of the evidence of this second digital divide.

Teachers and schools in particular can make a difference for those pupils who lack the appropriate cultural and social capital to benefit from digital media use in a way that becomes significant for their educational performance. If teachers and schools failed to acknowledge this second digital divide, and act accordingly, they would be in fact reinforcing its emergence.

In this discussion it is important to realise that the fact that they appear to be technology savvy does not imply at all that they have also developed the right set of skills and competences that would make of them responsible, critical and creative users of technology. The fact that educators, parents and particularly teachers, are less technology savvy than young people should not be anymore an excuse for giving up the educational responsibility on the development of the 21st Century skills and competences.

To adopt holistic policy approaches to ICT in education.

While it is clear that the availability of computers and internet connections at schools is a pre-requisite for ICT use, this can be considered to be a necessary but not sufficient condition. In addition, the availability of educational software and other digital learning resources and the ICT competences of teachers are equally important factors to guarantee a broader and more efficient use of ICT in the teaching and learning processes, both at school and at home. Further investments in this type of policies could enhance the development of new ICT-based pedagogies that would result in the wider application of those technologies that students are increasingly and widely using at home for mainly, recreational purposes, to the educational sector. Moreover, it must be noted that these three investment policies are closely interconnected between themselves and with ICT use. Higher levels of ICT use could result to higher demands for more and better quality digital content and higher levels of teachers' ICT competences, creating potentially a virtuous circle.

Certainly, besides public investments, there are other factors that could improve the ICT use in schools. An ICT overall favourable environment, the inclusion of ICT in the curriculum design or a strong leadership and commitment from teachers and head masters to implement ICT-rich teaching are also factors that could very importantly influence the use of ICT in schools.

Perhaps, as the PISA 2006 data show partially, one of the limitations that many educational ICT policies suffer from is that most countries have not developed holistic policies addressing all those factors affecting the use of ICT in a coherent manner, and the current results should give food for thought to critically evaluate the implemented policies and their results. As a result, countries should think of complementary policies that could maximise the effects of the already deployed infrastructure investments.

To adapt school learning environments as computer ratios reduce and the availability of digital learning resources grows.

In their traditional form, schools are not the right learning environment for the development of the competences required by today's society and economy. If the development of these competences is meant to be a crucial framework for school work, then a particular learning environment has to be developed. In such a learning environment, access to digital media should be easy and students should be able to locate and use a computer anytime according to the particular needs of their individual and team assignments.

Although there are indications of innovative developments in this direction everywhere, it is clear that governments should provide the conditions for these innovations to occur –and to assess their effects. Two particular areas which deserve public policy attention are computer ratios and the availability of digital learning resources.

Benefitting from recent technology and market developments, a number of countries, in the OECD and elsewhere, have begun to experiment with one-to-one computing (one computer per student). Although it is too early to say what are the results of these experiences as to endorse the principle of one-to-one, it becomes increasingly clear that today's average ratio of students per computer (5 in 2006, same in 2003) is not good enough to provide substantial opportunities of computer use in schools. Definitely, governments have to explore the opportunities brought about by new technology and market opportunities and do an effort to invest in low-cost computers when replacing desktop machines. This alone could result in better ratios and increased availability of computers for student use, as low-cost computers are mostly laptops.

Availability of digital learning resources should be the second priority in the development of these new learning environments. Nordic countries in particular[3] have addressed this issue from a variety of initiatives, counting on government-led efforts, textbook producers, and public broadcasting companies and, more recently, supporting bottom-up initiatives created by communities of user-producer teachers.

To promote an increase in computer use at school and experimental research on its effects.

As mentioned earlier, the PISA 2006 data have unveiled a number of interesting messages in terms of ICT accessibility and use by fifteen-year old students. More precisely, the data show that while there is increasingly a better ICT infrastructure available in schools in terms of computers and internet access, its use still remain weak, especially if 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 the direct result of only 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, as infrastructure investment may not suffice to do so

One of the most striking findings of this study, and of previous ones as well, is that even accounting for the socio-economic status of the student there is a significant correlation between computer use at home and educational performance, and such a correlation does not appear at all with computer use at school.

Some analysts have rightly pointed out to the fact 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 be seen in the presence of a successful educational strategy.

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[3]. As seen in the OECD study on Digital Learning Resources as Systemic Innovation in the Nordic Countries. More at www.oecd.org/edu/systemicinnovation/dlr

Therefore, the amount of use, i.e. the time a computer is used, would not matter at all. This certainly makes a lot of sense from a strictly educational perspective, but fails totally explain why substantial gains in educational performance can be 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 the 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 the actual frequency of use is currently irrelevant. Positive gains emerge from computer use at home because the frequency of use has reached a critical level. Such a frequency, according to the existing evidence, is far from the one than a student currently experiences at school, which can probably be defined as marginal.

Clearly, an increase in the frequency of computer use at schools cannot be obtained by simple governmental regulation. Use will increase only as an implication of teachers and schools commitment to the development of 21st Century skills and competences, and to their struggle against 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 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. Such an increase could be taken in the future as a clear indication of teachers and schools engagement with the development of 21st Century skills and competences, but it can also be expected to lead to gains in educational performance.

Governments need to create incentives for this. 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 successful yet in cumulating an evidence base from which teachers can obtain clear guidelines for improved practice –at least partly this is an implication of the scattered qualitative case-based research that seems to have dominated the field. It is in the best interest 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 depict a more nuanced picture on the availability and use of ICT, as well as their 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 of the current questions or introducing some new ones. In particular, more precise data would be needed in terms of ICT use as the current questionnaire allows for potentially large disparities in ICT use under the same categories. For example, the use of almost every day could be identified as the appropriate answer for students who use ICT 15 minutes per day, and those using it 5 hours. In addition, the questions related to the types of ICT use should be modified to reflect the needs to measure more accurately the 21st century competences, such as editing, revising, writing, working on spreadsheets or preparing presentations, instead of measuring the familiarity with basic IT tasks. Equally, the questionnaire could introduce some new dimensions in current questions, *e.g.* use of digital learning resources for school work both at home and in school, classify by subject. This would provide important data for understanding the development and effects of policies aiming at developing 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 on ICT uptake and use in education are missing. Although PISA studies will remain one of the most important sources of evidence in this domain, knowledge economies and societies would greatly benefit from a broader set of indicators. These could monitor progress in ICT uptake and unveil important information about use, ranging from issues such as frequency to purpose and effects. If carried out in an international comparable framework, like the one OECD provides for indicators in education, they will 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 of what is currently known comes from declarations (students, teachers and head teachers) and not from direct observations. As already argued above, large-scale experimental research and panel studies can make an important contribution to enlarge the evidence base on ICT in education.

Finally, these new data should be analysed in order to understand better the determinants and effects of ICT use in school and at home and on the causality of ICT use on educational performance, the development of 21st Century skills and the improvement of the quality of the teaching and learning process. In doing so, better informed policies could be drawn enhancing the potential effectiveness and efficiency of policy design and increasing public accountability.