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THE NEW MILLENNIUM LEARNERS: MAIN FINDINGS

Purpose of this document

This paper offers an account of the preliminary findings which the project has cumulated so far. Its main objective is to feed the ongoing discussions about the impact of technology on learners, by taking stock of what the existing empirical evidence is telling and identifying areas that would eventually benefit from further exploration in the current phase.

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INTRODUCTION

1. The CERI Project on the New Millennium Learners (NML) started in 2007 with the global aim of investigating the effects of digital technologies on learners, particularly of school age, and providing some recommendations on the most appropriate institutional and policy responses from the education sector. The project planned for two different phases, adopting a classical approach: a first phase was designed to explore the demand side, i.e. the changes experienced by learners, if any; a second phase will be intended to review current and emerging educational responses.

2. This paper offers an account of the preliminary findings which the project has cumulated so far. Its main objective is to feed the discussion about NML by the CERI Governing Board, by taking stock of what the existing empirical evidence is telling and identifying areas that would eventually benefit from further exploration in the current phase.

3. Accordingly, the paper is divided in three main sections plus an annex. A first section offers an update of the evidence base that was already presented in the first background paper of this project[1]. A first issue here is how fast digital technologies and services have become an integral part of the daily lives of children and teenagers across OECD countries, and how far their relationships with these technologies shape their activities, including how they manage social interactions and knowledge. But the second and most important issue is how far the concept of NML is of application to all OECD children and teenagers. In this respect, the section claims that, irrespective of how attractive the label of NML may be, by no means it should be used to describe a generation-wide phenomenon because the effects of digital technologies on learners are deeply influenced by factors such as age, gender, and socioeconomic status. Therefore, the generational approach adopted by most analysts and essay writers cannot be sustained empirically. Contrarily, there is enough evidence to claim that the an unduly neglected issue such as the role of digital technologies in the amplification of divides among children and young people has to be taken seriously both by educational institutions and policy makers. A second section presents and discusses the main research findings in controversial areas such as the effects of technologies on cognitive skills development, social values and lifestyles, and educational performance, and unveils how little is known. The final section presents the areas that have not been addressed yet in the project because their relevance has not emerged until lately and discusses also how the voices of NML could be taken into account from now on in the development of the project.

Are NML a case for education policy making?

4. It is obvious that an increasing percentage of children born in OECD countries grow up in societies where Internet connections, mobile phones and videogame consoles are on average easily available. Although some analysts may claim that there is no need to worry about this because it is not the first time in history that a technology emerges and is adopted very rapidly, there is something new in this opportunity. Contrarily to what happened previously to older generations when radio and particularly

1. An updated version of this background paper was published under "The New Millennium Learners: Challenging our Views on Digital Technologies and Learning" (Pedró, 2007).

television emerged, digital technologies and the services associated bring in something completely new: they modify not only the speed at which people deal with information but moreover the ways in which people manage it in the broadest sense. From a purely rational perspective this is a good starting point to wonder about the implications that this fact may have when the users are children or young people, particularly as access to digital technologies becomes almost universal in OECD countries.

5. In this context, this section addresses two different issues which can give some ground to the NML case: first, the rhythm of technology adoption by children and young people and how this is far from being matched by the actual use of the same devices and services by educational institutions; and, secondly, whether the concept of NML, other than being instrumental to evoke the phenomenon of the eventual impact of digital technologies on learners, is as a matter of fact obstructing the required policy focus on how different might be the effects of technologies on different profiles of young people and how urgent is to develop adequate policy strategies to cope with the emerging divides.

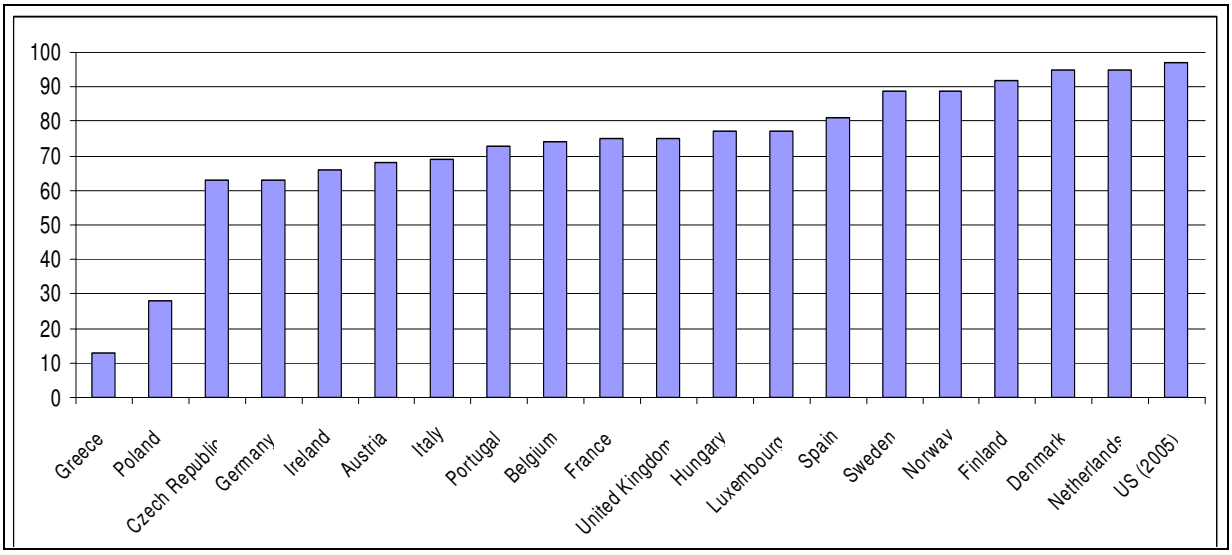
Technology everywhere, except at school

6. To begin with, this section offers a statistical overview of the situation in a number of OECD countries for which the project has gathered data. The resulting picture shows some degree of variation but in general the speed of technology penetration into children's and young people's lives mimics the rate of adoption at home level. According to the last PISA survey (2006), 86% of pupils aged 15 use frequently[2] a computer at home. As a matter of fact, in 21 out of the 30 OECD countries the actual percentage is higher than the mean, and in five countries is even higher than 95%. Based on the growth experienced in these rates since the previous PISA survey, in 2003, it can be projected that by 2009 using frequently a computer at home will become a universal feature of young people aged 15 in most OECD countries.

7. The comparison with the situation in schools is inevitable. In the schools sector, the rhythm of investments in technology, intended to facilitate its adoption, has been generally impressive in OECD countries. However, it is well known that the results in terms of real adoption fall really short and do not match the initial expectations at all. The following two figures provide a clear indication of this by comparing, on the one hand, the degree of broadband penetration in primary and secondary schools with the percentage of teachers and students who declare not to have used at all a computer in the school during the past 12 months.

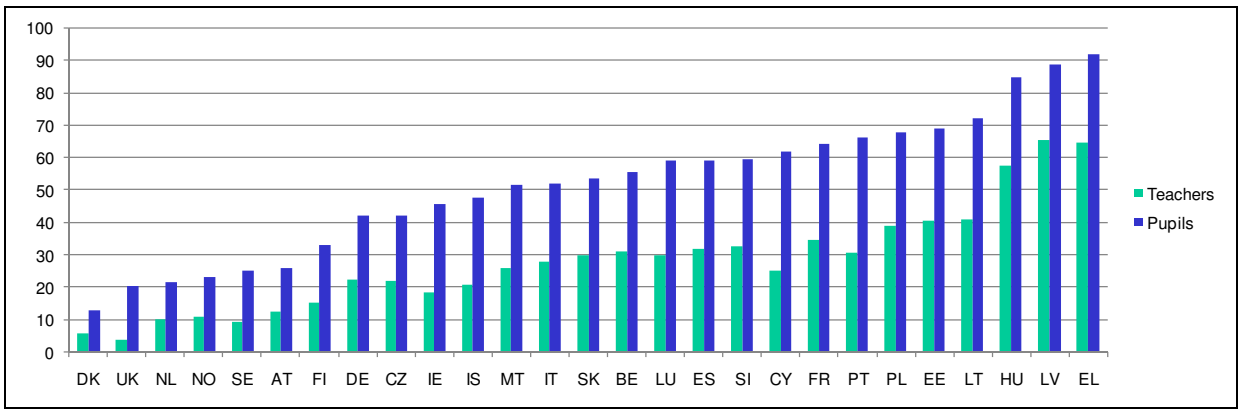
2. Defined in PISA as daily or a few times a week.

Figure 1. Broadband in primary and secondary schools in some OECD countries (2006 or latest available year)



Source : National statitiscal offices, Eurostat, and US Department of Education (value for 2005)

Figure 2. Teachers and pupils in primary and secondary education who have not used a computer in the classroom in the past 12 months in EU countries



Source : Empirica, 2007.

8. On average 50% of students in EU countries declared not to have used a computer in the classroom in the past 12 months. Overall, the comparison with what could be done in theory looking at the availability of technological infrastructure, as measured by the degree of broadband penetration, makes inevitable the discussion about the infrautilisation of technologies in the classroom. Secondly, it raises the issue of the differentiation of practices in the management of social communication and information according to the *locus*, be that the classroom or outside the classroom. And, thirdly, the different appreciations expressed by teachers and students have to be noted as well. The lower levels of non use of computers declared by teachers might well be related to the fact that they use the computers only for presentational purposes, without pupils being required to carry out any activity on a computer. However, such a big disparity, which in the better cases reduces by half the degree of non use by teachers as compared by the one declared by pupils, rises also the issue of the difference between declared and actual teaching practices.

9. Therefore, there is a NML case built on the eventual contradiction and perplexity that students may experience when realizing that digital technologies are so important in their daily lives, as well as they are also in the world of adults particularly at work, except when they are in classrooms –when even mobile phones are usually banned. Even worse, they can even see that an important technological infrastructure is in place, but underused. A quite different argument, which is discussed in the last section of this report, is whether when technologies are actually used in the classroom, pupils' practices and expectations are matched by teaching practices or not.

A second digital divide as policy concern

10. The second issue examined in this section provides a further indication of why NML should be considered a case. The main issue at stake here is that the use of generic labels such as NML fail to provide an accurate account of how differently digital technologies affect diverse categories of young people and how the interaction of technology adoption with important variables such as gender and socioeconomic status, if duly taken into account, can give rise to real policy concerns. Both issues are examined here.

The gender issue

11. Research has repeatedly pointed out to the existence of a wide gender gap concerning ICT. Boys use computers and the Internet more than girls, have wider computer experience, spend more time online, report greater interest in and perceive more positive attitudes to computer-related activities, boys also appear to be more motivated to learn digital skills (Arnseth, 2007; Broos, 2006;(OECD, 2003, 2007); OECD & PISA, 2005). Contrarily, girls seem to be dominating in the communicative field of ICT, like word processing, text messaging on cell phone, as well as e-mail and blogging (Lenhart, 2007; OECD, 2007).

12. The importance of this gender gap is twofold. On the one hand, it raises the issue of whether the concept of a knowledge society, where technology is playing such a critical role, will in the end become mostly a male-designed model of society. On the other, it is often cited as a source of political concern in view of the lower proportion of women in computer science and in ICT related professions, which seems to be static or declining, even in cases of sustained inclusion efforts (Falkner and Lie, 2007). If women are not equally participating in the design of new technologies and applications the risk of developing a male-centred approach only increases.

13. However, behind this discussion it often lays an understanding that the girls are somewhat falling behind (Tomte, 2008). Meelissen and Drent make an interesting point when they highlight the fact that this discourse is only valid if one consider the boys' use as the norm and as a representative of the actual goals to reach (Meelissen, 2007). Also other researchers highlight this, for instance Sørensen, Jøsok Gansmo and Lagesen (Gansmo, 2004; Gansmo, Nordli, & Sørensen, 2003; Lagesen, 2008; Sørensen, 2002). However, most of the research done so far is actually based on the actual point of departure, which supports the view that girls are falling behind the boys when it comes to ICT, in terms of self attainment, attitudes, patterns of use and so on.

14. There is no general consensus yet about how to disentangle the gender issue in this domain, and whether targeted educational policies and practices have to be put in place[3]. Be that as it may, the point is that the concept of NML risks evoking the exclusive image of a boy who is spending most of his time playing videogames. If such a concept is aimed to embrace both boys and girls, then the image has to be far more complex, ideally in such a way that even gender-based dualisms should be avoided.

3. And this is a major concern in the context of the NML project, in which context an expert meeting devoted to this issue is being prepared.

The Mathew effect

15. The issue of access to technology seems to be almost irrelevant in most OECD countries, although not yet in all of them. On the basis of this, the concept of NML tends to suggest that there is a standard and quite homogeneous approach to technologies shared, for instance, by the average OECD teenager. Once again, this is an oversimplification which underestimates the impact of socioeconomic status.

16. The impact of socioeconomic status asks for a refined approach to the effects of technologies on learners. First, in each OECD country there is still a percentage of 15 year olds not having access to technologies. Second, even in those cases where access is granted, a second digital divide emerges –it is not anymore about access, but about differences in use. Third, this second digital divide acts according to the pattern of the Mathew effect and, if no political intervention is made, may increase existing socio-economic divides. And, unfortunately, there is not much evidence that this issue is in the agenda of educational policy makers in OECD countries.

17. Although it can be claimed that there is an almost imminent horizon of universalisation of access to technologies by 15 year olds, the fact is that in all OECD countries still a percentage of them do not have access at all to a computer connected to the internet. This is on average a 14% of all 15 year olds, a figure high enough to constitute still a policy concern, particularly because it is well known that this goes beyond a mere technological issue and is clearly connected to social and economic disadvantages as well.

18. But even in those countries where access to technology does not seem to be a matter of concern, because of the pace of technology penetration in homes, the issue of whether all children and youngsters use the computer, the internet or mobile phones in the same way or not, has to be raised. Very little is known about this from a comparative perspective, but from the existing limited evidence it emerges very clearly that, for instance, the uses of the Internet, particularly the balance between leisure-oriented and learning-oriented activities, strongly depend on a number of family variables such as parents' educational level, experience and frequency of Internet use, which are in turn extremely connected to their socio-economic status (Mominó, 2008). Family's cultural capital is undoubtedly reflected also in parents' Internet practices and therefore influences as well children's and youngsters' approaches to technologies (Pasquier, 2007). Whether this influence is stronger than the one exerted by peers remains unclear, but as peers tend to share, for a number of reasons, a similar socio-economic status, the result cannot be other than a reinforcement of the influence of the cultural capital on technology-related practices.

19. This last point raises the issue of the Mathew effect (Merton, 1968). It can be reasonably expected that those who already have a good cultural capital will find in their technology-related practices a way to reinforce it, while those who either do not have access to technology or lack a well sound cultural capital will be lagging behind. In the long run, the existing differences between those who have and those who haven't the right cultural capital to take advantage of the potential of technologies will increase. Hence the Mathew effect: those who benefit from a better socio-economic environment find easier to benefit from technologies, thanks to the cultural capital transferred to them, and thus increase their advantage and privileged situation in comparison to those who lack such an accompanying capital. In other words, if no compensatory policies and practices are in place, granting access to technology to children from socio-economic deprived contexts may look like a good step to break the technology gap, as it was originally defined in terms of access. However, a second digital gap is emerging and to bridge it would require a new set of educational policies and practices, as it is related to technology practices associated to cultural capital.

20. Both gender and socio-economic status do not seem to be at the forefront of current educational research on technology. But they should, as both issues challenge the prevailing homogeneous and

comfortable assumptions regarding the positive effects of technologies that the common policy discourse usually contains. NML may be a good brand to suggest that there is an urgent need to know more about the effects of technologies on learners, but it would be misused if it only served to the purpose of drawing attention to a fictitious image of empowering effects on all children and youngsters equally.

THE EFFECTS OF TECHNOLOGIES ON LEARNERS

21. This section presents and discusses the main research findings[4] in controversial areas such as the effects of technologies on cognitive skills development, social values and lifestyles, and educational performance, and unveils how little is known.

Cognitive skills development

22. The evidence from research on the impact of digital media use on cognitive skills is difficult to generalize, as it is always placed in context and set in relation to a number of factors such as age, gender, socio-economic background, time spent in computer activities, preference for certain activities. However, the majority of inquiries in this regard examine how the intended use of digital technologies in the form of training affect certain skills, competencies and behaviours. Although such evidence might not show how technology use changes young people in broad terms, it improves our understanding of the processes taking place and enables the development of interventions and learning scenarios. Additionally, some of the effects observed in controlled environments can be expected to occur in the everyday interaction of young people with educational software, computer games or the Internet.

23. At least potentially, digital media contain features which provide opportunities for enhancing various cognitive skills. Throughout the years their use in formal and informal setting has been related to training or effects on memory skills, attention, executive functions such planning and strategy use, language, thinking and visual-spatial skills. Research in these areas has taken various directions: understanding how different digital materials are processed, what cognitive abilities they activate and affect; how mental models are built from digital aids; how to train certain cognitive skills in the context of academic learning; how the use of computers and the Internet at home for playing games, searching for information, and communication affect cognitive skills. However, it has to be pointed out that most of the research addressing issues to do with ICT and cognition has been qualitative in orientation, addressing issues to do with how ICT facilitates reasoning rather than with how it has discernible effects on cognitive processes and representations. Moreover, quantitative methods are used to study interrelationships between personal/cognitive and situational variables, rather than in order to experimentally isolate the effects of ICT on cognition something that would make the research less ecologically valid (Arnseth & Ludvigsen, 2006).

4 . The contents of this section are mostly, but not only, based on the research reviews conducted in a number of OECD countries, in clusters according to language or cultural affinity (English, French, German, and Spanish language, plus a review of the Nordic countries). Korea has contributed also with one national review. These reviews are still in the process of being finalised and therefore the results presented here have to be considered provisional.

Visual-spatial skills

24. Probably the largest part of the empirical research regarding the impact of digital media use on cognitive skills focuses on the development or training of *visual-spatial skills*. Many computer applications have design features, which require visual rather than verbal information processing. The constant enhancement of the graphic design and realism of video games in the last years presents new dimensions of spatial, iconic, and dynamic features, which provide a new environment for children to develop a set of skills concerning visual attention, orientation, and spatial representation. The abilities to deal with two- and three-dimensional images, spatial visualization, and skills to read images, the ability to recognize the information which images contain, as well as the ability to interpret images are expected to improve with repeated practice, for example, through the regular use of multimedia and computer games.

25. The most quoted overview of the research on promoting spatial abilities through computer games (Souvignier, 2001), has found consistent evidence that such skills can be improved through drilling and practising, as it happens when playing videogames. However, the present state of the evidence does not indicate that engaging in computer games, which are based on spatial information, automatically leads to an improvement of spatial skills, which can be transferred to new contexts or to a broader range of spatial abilities. While research shows that by way of playing videogames visual-spatial skills can be improved, it is not conclusive about the degree of transferability of such an improvement.

Memory skills

26. Another frequent topic is the impact of digital media use on memory skills, which has received a great deal of attention in relation to the research on the impact of violent media content on young people. While some structural features of multimedia facilitate retention, it is argued that strong emotional experiences during interaction with digital media might hinder memory skills and the long-term effects of learning. The assumption behind this hypothesis is that emotional events influence how things are perceived and remembered. For instance, in cases of victims of violence, elements of the events often cannot be recalled. The major concern is that nowadays computer games and movies are made to provoke strong emotional responses, and that engaging in such activities after learning would decrease the learning effects from school or homework. Mößle et al. (2006) report such a correlation between longer playing times of computer and video games and low academic achievement based on a survey of 6000 4th-graders in Germany.

Higher cognitive skills

27. The influence of ICT use on tool utilization, reasoning capability, and judgment has been shown to be relatively small, while there are many studies regarding the influence of ICT use on research ability, information processing ability, reflective thinking ability, critical thinking ability, creative thinking ability, and meta-cognitive thinking ability. As the subjects for domain-specific ability were mainly secondary school students, and the subjects for general ability were mostly adult learners, it is necessary to verify the influence of ICT on the general ability of secondary school students.

Limits of available evidence

28. Most of the criticism in regard to assessing the impact on cognitive skills is connected with taking measurements immediately after practicing, while the cumulative effect of digital media is not sufficiently examined. Although the reviewed findings reflect a mostly intentional training of cognitive skills, and not the effects from everyday use of digital technologies, the same mechanisms can be expected to operate in natural settings. Thus, most of the uses of digital media involve complex processes and are influenced to a large degree by structural design features, perception and cognitive properties. However,

constructing mental models and internalizing concepts from using different computer applications and the Internet also influences how young people think, approach tasks and socialize. One of the major questions regarding the role of digital technologies in young people's lives concerns how the socialization processes and social behaviour are influenced by the increasing spread and use of computers and the Internet.

Social values and attitudes

29. The availability of technology and some criticized features of digital content, particularly in videogames, such as the stereotyping of women and minorities and the enforcement of violence, have raised concerns about the long-term effects on the identity and social development of young people. However, the question of the actual impact of using digital media on young people's skills for building and maintaining social relationships, on their views, attitudes and behaviour, is also a question of the differences in media availability and use among social groups.

30. Belonging to a social group with specific values, lifestyle, cultural practices and preferences naturally affects media socialization, and while for young children the family circle is a deciding factor, youth culture gains importance for adolescents. The social milieu approach in examining the use of media by young people has already proven useful for explaining television habits and preferences, however it has not been explored in regard to digital technologies and research in this direction can be expected to contribute to the development of this field. The different uses of computers and the Internet according to age, gender and educational level leads to additional inequalities. Thus, digital media use is determined by age, gender, educational characteristics, as well as environmental influences such as the values and preferences of parents and peers.

31. The various uses deepen the discrepancies between the social groups through the respective development of competencies, learning styles and strategies, as well as attitudes and values, which then affect outcomes and life and career paths. So, in many different ways, it appears to be the case that it is not so much that technology use has an influence on attitudes and social values, but that rather, it is the other way round: attitudes and social values affect technology use.

The paradox of socially-connected isolation

32. The increasing use of computers and the Internet by children and adolescents has also been connected to concerns of isolation tendencies and the hindering of the development of social competencies. Indeed, in most OECD countries the proportion of children and young people with digital devices in their rooms has increased, but at the same time the devices are used more frequently than before for communication purposes through a variety of applications, and even more since the emergence of Web 2.0 social applications. This is specifically popular among teenage girls. As a result, youngsters tend to project an image of isolation, as they look as if they were concentrated in their own inner life –but as a matter of fact they are most of the time interacting socially with others, while being continuously on-line or texting messages.

33. Despite the clearly increasing digital media use for social purposes, it is not immediately obvious how this affects inter-personal skills and social resources, as it becomes clear that social and communication applications are used primarily to keep up with close friends and close family members, and the use of the computer for e-mail in these online relationships supplemented the telephone and face-to-face visits, but rarely replaced the older modes of communication.

The effects of videogames

34. Apart from the issue of the digital inequalities and the implications for the social development of young people, digital media use is also explored in relation to the values and models for social conduct, which it transfers. This is particularly true for computer and video games, which convey interpretations of reality, social relations, and events, but often in simplified and stereotyped form. However, only in very rare occasions are players under the illusion of the virtual world and view their behaviours in the game world as transferable to real world. Therefore, the opinions regarding the role of computer games in young people's life are contradictory.

35. The debate about the effects from playing computer games with violent content has been heated again by recent findings, which attract enormous media attention when they point out to the negative effects of playing videogames. Spitzer (2007) stated that violent content influences brain processes and is related to development of aggressive behaviour, which would eventually lead to increase in the criminal events in future. In an overview of the different positions in the debate Lukesch (2002) notes that more than 100 studies had explored this relation, but a large proportion of the participants in the discussion base their arguments on subjective experiences, rather than on empirical findings.

36. Although the existing evidence does not give conclusive answers to questions of effects of different technology uses on the social development and behaviour of young people, it indeed indicates that its potential harmful impact cannot be overlooked. Therefore, it is necessary to explore how these negative effects can be weakened or prevented. Despite the attempts of governments to limit the possible access of children to violent content, this can easily be circumvented with help of siblings, friends, and even parents. It seems that the secondary parental control of the digital media use of children and adolescents is of primary importance, and parents need to be alerted about the dangers of the opportunities new technologies create. This can also be a subject of media education directed at the parental body.

37. However, the most beneficial option would be to equip young people with knowledge and competencies that would enable them to navigate in the online spaces and virtual worlds with less harm instead of relying on external control. Such interventions are particularly suitable for schools, because of the potential to reach every child or adolescent. Clarifying the functions of digital media and the differences of the conflict resolution strategies and social actions between virtual worlds and real life should be part of training programs with such purpose. The identification of risk groups and effective interventions are the first steps toward more practice-oriented research.

Educational performance

38. The analysis of something apparently as simple as the impact of ICTs on the quality of education does not seem to have found an easy answer so far. In theory, it should be possible to answer this question by analysing the results of educational research by means of empirical experiments or analysing the correlation between ICT use and educational attainment, and both ways are presented below. In practice, however, there is no conclusive evidence about the effects of ICT upon academic achievement. This is partly for obvious reasons – they are teaching means that can be used with a wide range of methodologies and strategies – and also because insufficient effort has been made about evaluating a relationship as complex as the one between ICT access, frequency of use at school and out of school, and academic achievement.

Empirical experiments

39. Experiments can only attempt to determine how effective ICTs are in teaching specific school subjects, due to the multitude of compartmentalised methodologies to be found in a single school, and even

in lines or different groups of students studying the same subject, albeit with different teachers. Consequently, the experiments designed to date compare the educational attainment of a group of students using an ICT-rich teaching methodology with the achievement of another group with similar characteristics being taught using traditional methods. The preferred subject for this type of analysis is usually maths.

40. There is a generalised belief that, over all, the "no significant difference" phenomenon, documented on many occasions in the case of distance learning, also emerges in school education. According to this, there is insufficient evidence to affirm either the superiority or inferiority of ICT-rich methodologies. This would seem to be the outcome of the two systematic reviews of literature conducted recently, which conclude that "in general and despite thousands of studies about the impact of ICT use on student attainment, it is difficult to measure and remains reasonably open to debate" (Infodev, 2005), and also 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).

41. 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, increased significantly in this field. Even very young primary school pupils using computers to write their own stories ended up improving their marks in reading. In short, there is a positive correlation between the frequent use of word processors and improved writing-related capabilities.

42. One must, however, wonder to what extent these proven improvements stem from the use of ICTs or if they are simply due to a greater degree of practice in the skills being assessed. In other words, neither the number of computers available nor how often they are used would seem in themselves to be determinant factors. Success would rather seem to be linked to a strategic use of ICTs within the framework of a pedagogical model in which they are assigned a specific role consistently over time. The problem is that these models have apparently yet to be well defined, therefore it is not surprising that agencies such as *Center for Applied Research in Educational Technology* (CARET)[5] emerge, whose basic role is to disseminate research results and convert them into advice and strategies to enable ICT use to lead to improved educational attainment.

Correlation analyses

43. Studies of this sort try to demonstrate whether there is any correlation between ICT 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.

5 . CARET (http://caret.iste.org) is a project by the International Society for Technology in Education in partnership with Educational Support Systems. CARET was founded in the year 2000 with a grant from the Bill & Melinda Gates Foundation.

44. Analysing the studies conducted to date again suggests that there is no consistent relationship between the ICT availability and use, on the one hand, and educational attainment, on the other. Examples of studies about ICT 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), whilst others demonstrate the complete opposite (Angrist & Lavy, 2002; Pelgrum & Plomp, 2002). It is even possible to find references (Ungerleider & Burns, 2003) to a certain number of investigations demonstrating that the more computers are used in the classroom, the worse academic achievement is.

45. The same inconsistency occurs in the analysis of the relationship 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, & Rush, 2003), but there are others that conclude the complete opposite (Wenglinsky, 1998), including a comparative study of 31 different countries (Fuchs & Woessmann, 2004).

46. The analysis of the PISA results (2003) has helped clarify the circumstances in which conclusive statements can be made about the correlation between ICT use and educational attainment. In more than one respect, PISA shows that this relationship is not linear but extremely complex. Consequently, if this is the case, it is hardly surprising that complexity is mistaken for inconsistency.

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

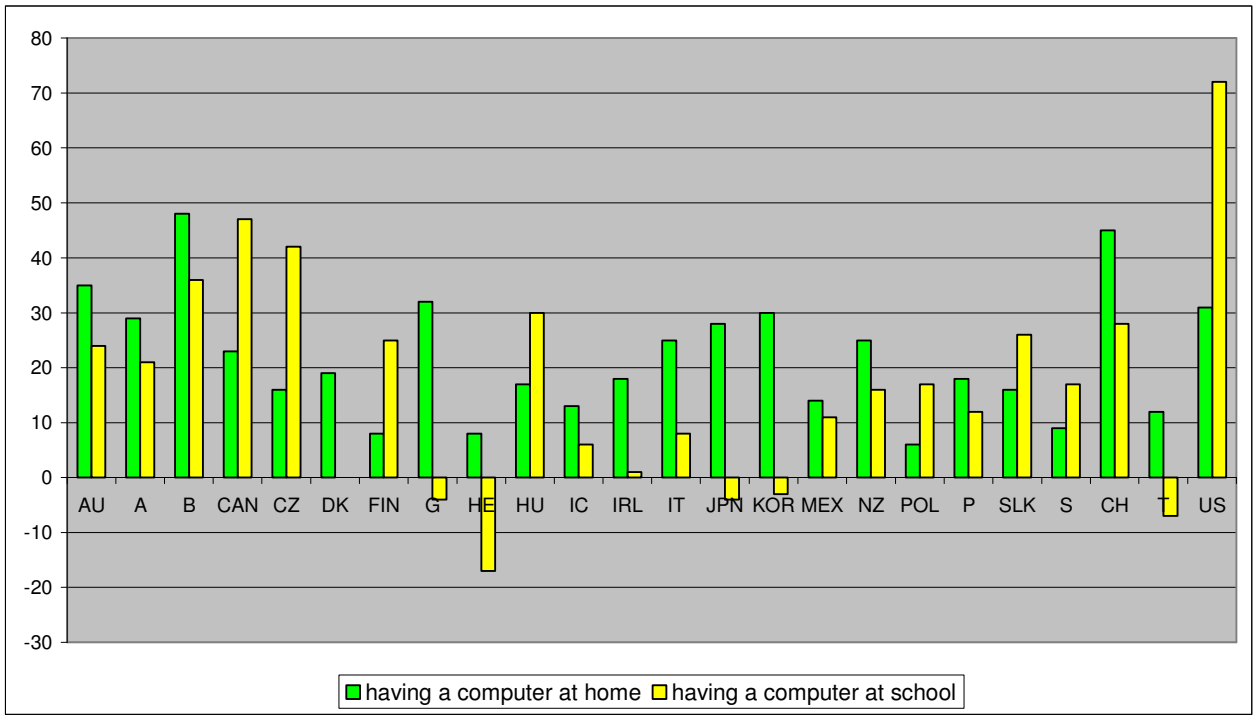
- *Access*: most students who still have limited ICT access obtained below-average PISA results.
- *Previous experience*: the lower the experience in ICT use, the lower the PISA result. Students with less than a year's experience were only capable of the simplest maths exercises.
- *Frequency of use*: the supposition that more frequent use gives better results is not the case in all countries. An in-depth analysis shows that students with moderate ICT 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.

48. What is equally or more interesting than these correlations are the conclusions that can be drawn from ICT use at home and educational attainment, also on the basis of the PISA database (2003). Probably the most important of all of them is that the correlation between home use and academic attainment is greater than in the case of school use in most countries, even when allowances are made 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 and, secondly, it would also seem to be proven that students using computers at home less often had below-average results.

49. All these conclusions pose very interesting questions about the prior assumptions concerning the impact of ICTs upon educational attainment. In this respect, figure 4 shows the differential in marks obtained when ICTs are available at school or at home, in comparison with students without, making allowances for the effects of different socio-economic backgrounds.

Figure 3. Computer access at school and at home and academic achievement

Different ratings on the PISA scale between students with access to a computer and those without, after allowing for the effect of different socio-economic backgrounds



Source : PISA database (2003).

50. The impact of computer availability at home upon academic attainment is clearly higher, in most countries, than the effect of access at school, although there are noteworthy exceptions including Canada, Czech Republic, Finland, Hungary, Poland, Slovakia, Sweden and the United States. The reasons for these links require further analysis, as do the reasons for the exceptions. Secondly, and no less surprisingly, there are even countries where the correlation between computer access at school and academic results is negative, as in the case of Germany, Greece, Japan, South Korea and Turkey.

EMERGING ISSUES AND FUTURE DIRECTIONS

51. This final section presents the areas that have not been addressed yet in the project because their relevance has not emerged until lately. In most cases, they did as a result of the work being carried out in other areas. First of all, there is the issue of why student teachers, who might be expected to be NML, are not able to transform their private technology practices into professional assets. Second, there is the so-called Web 2.0 and its impact when learners become digital content producers. And finally, there is the need for designing ways in which the voices of learners can be brought in the discussions about the effects of technologies on them as learners, particularly as regards their expectations. Answers to these three issues would certainly contribute to a better understanding of the demand side of the NML.

Are teacher students NML?

52. Although some studies in OECD countries show that teachers might be amongst the most skilled technology users, it appears to be that they are unable to take advantage of their competence and apply it to the way they teach. A number of reasons can be used to explain this paradox, but three emerge as the most salient:

- The absence of appropriate incentives to use technology in the classroom and, more in general, getting involved in any innovation;
- The dominant culture in the teaching profession, which does not rely very much on research-based evidence to identify good teaching methodologies and strategies;
- Teachers lack the vision and the personal experience of what a technology-enhanced teaching could look like.

53. While the first is related to the configuration of education systems and, particularly, to career development in the teaching profession, in the other two it seems to be clear that the experience of initial teacher training can be an important determinant. From what is known, it can be inferred that teacher training institutions are not doing well at providing student teachers, not only with the vision, but, what is even more important, the required hands-on experience of learning with technology (Kleiner, Thomas and Lewis, 2007). This is particularly striking when taking into account that, from what is known, an important share of incoming teacher students, increasing year by year, might be considered NML, i.e. used to deal with technologies for the purposes of social communication and information management. So, either prospective teacher students are already disaffected from technologies or teacher training institutions prepare them in a way that distils such disaffection into them.

54. However, such an important claim regarding the role of initial teacher training in preparing teachers for an adequate in-classroom use of technology needs to be backed with empirical evidence. If this proves to be the case internationally, then there will be an urgent need for policy recommendations both for teacher training institutions and for governments in order to maximise the role that initial teacher training can play in offering a vision and a personal experience of a technology-enhanced education.

Does Web 2.0 make any difference?

55. The current understanding of how technology use affects learners and the research base which supports it are mostly based in a concept of learners as users or consumers of applications and services. However, in the last five years or so a new generation of applications and web-based services has emerged with the common denominator of allowing users to become producers and create virtual identities which allow them to engage in a number of social spaces and activities. Although, for instance, there is much hype about the so-called Web 2.0[6] and its educational potential very little is known about the effects of becoming a content producer with a potentially unlimited audience at a very early age and even less about the impact of creating and nurturing virtual social networks, be that through the net or by way of using mobile phones, and a particular idiom, to set up communities which, in many ways, operate free from any

6. As opposed to the original Web (version 1.0) where users mostly searched and downloaded information, Web 2.0 emphasises the role of the user as an active content-producer: people are expected to upload information, sometimes personal, share it with others, or engage in multiple conversations in a variety of ways ranging from blogs and wikis (such as the Wikipedia) to social applications intended to create and maintain communities with shared interests, values or links.

adult supervision. This raises a number of concerns and particular attention has to be devoted to issues such as safety, plagiarism, and the eventual impact of Web 2.0 in learners' expectations about education.

56. Safety in virtual spaces has been receiving increasing attention by the media. Even technology providers have developed a number of solutions intended to prevent access to inappropriate content, some of them to be used at home while others at schools and universities. All these solutions offer tools that are intended to enforce adults' supervision and let them to decide what is appropriate for a child or a student to look at in the Internet. But neither of them can be seen as substitutes for parental and educational responsibilities over children's upbringing. Both the generalisation of the use of cellular phones, with devices intended for children as young as 8 years old, and the widespread and viral penetration of social applications in the Internet allow them to generate *third spaces* whose rules, contents, inner life and, most importantly, actual members, some of them with faked identities, escape totally to any adult and responsible supervision.

57. The many and easy ways in which information can be found in the Internet, copied and pasted, has also raised concerns about plagiarism, particularly in university settings but increasingly also in schools. This is in fact an indication of the shortcomings of the lack of appropriate media education in schools, and the need to incorporate in curricula not only the technological skills required to manage information from a technical point of view, but also the values that inspire concepts which are difficult to grasp at early ages but may have a long lasting impact, such as intellectual property, academic authority, or even the difference between finding and downloading information and constructing knowledge, personally or collectively.

58. Lastly, there is the issue of whether new communication and information tools which really empower children and youngsters as content creators with particular identities may in the long run affect their expectations as learners and their behaviours in classrooms. Some would claim that because of this pupils are increasingly challenging teachers' and parents' authority, and that the virtual communities in which they participate make them to conform to values, rules and norms that defy those traditionally heralded in schools. Too little is known about this and more empirical research should be developed.

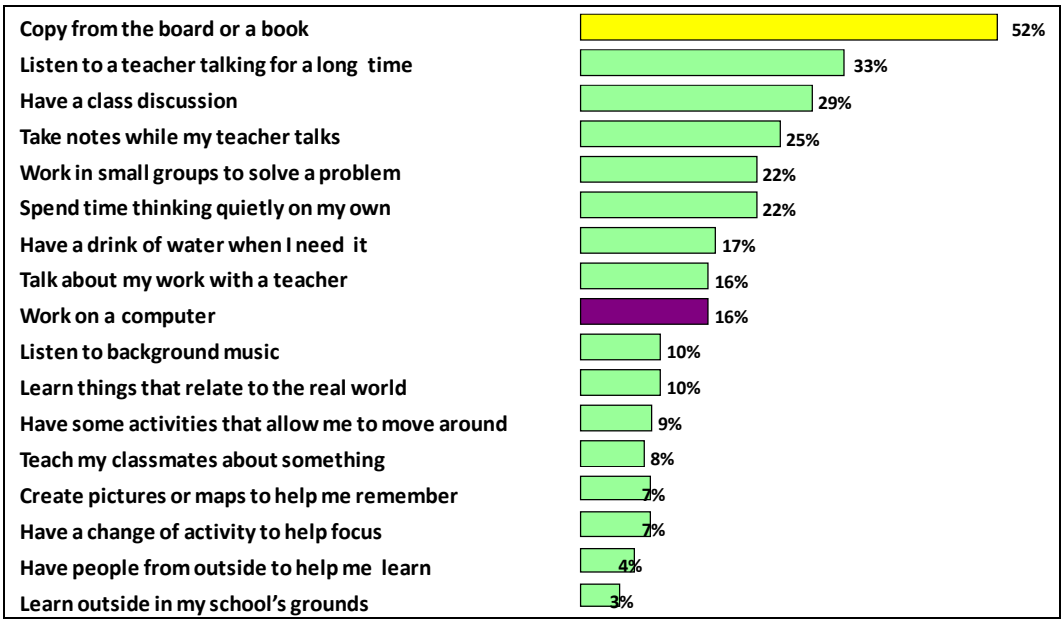
Bringing in the learners' voices

59. The very last point emphasises how badly educational systems and structures are prepared to pay attention to learners expectations and how difficult is for them to express their voices in ways that can be really significant to improve teaching and learning processes in general. In the particular domain of technology, it may be claimed that there are national surveys regularly, thus providing a clear indication of technology trends among young people particularly. However, it is unusual to have that kind of surveys in relation to teaching and learning expectations and the corresponding degree of fulfilment.

60. The next two figures provide an example of the relevance of the information that could be eventually gathered if the learners' voices were taken into account. They are both part of a national survey carried out by Ipsos Mori in England in 2007. They allow for a comparison between predominant teaching and learning practices in classrooms and pupils' expectations in secondary education.

Figure 4. Most common classroom activities according to English pupils aged 15

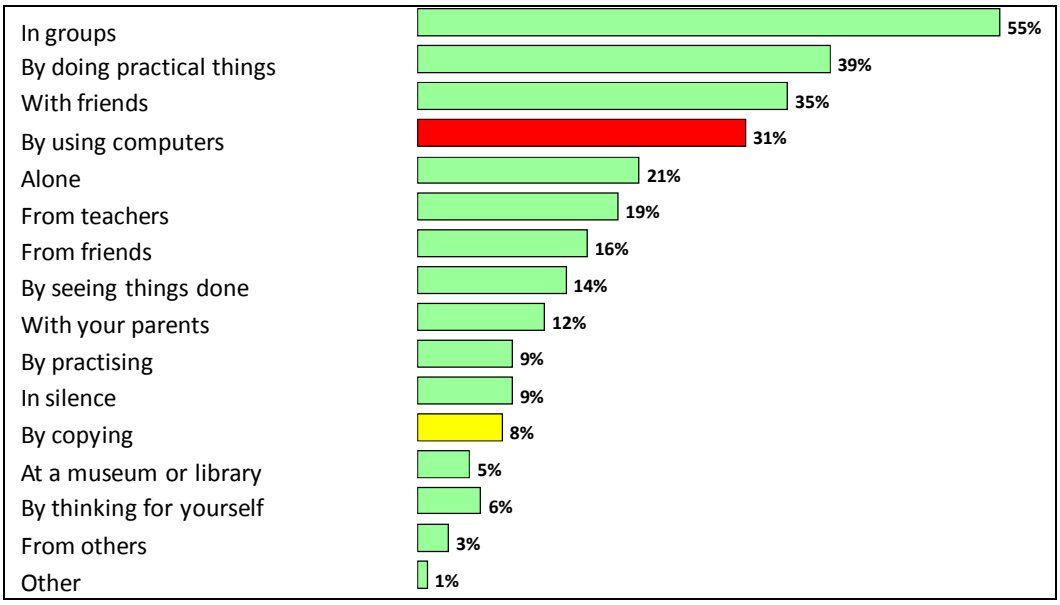
Q: Which three of the following do you do most often in class?



Source : Ipsos Mori (2007)

Figure 5. Most preferred ways to learn according to English pupils aged 15

Q: In which three of the following ways do you prefer to learn?



Source : Ipsos Mori (2007)

61. The comparison between the two figures is clear enough regarding the mismatch of current practices and expectations. The English survey points to the fact that predominant teaching and learning practices are far not only from matching learners' expectations, but more in depth lag behind in terms of

providing the recommended teaching and learning practices that current educational discourses, drawing on empirical research, claim to be most appropriate. And the point is that technology is just part of the picture and not necessarily the most important one. This is why a project like NML should invest more efforts in unveiling what the learners' perceptions of desirable changes in education are. If research points to the same direction, and this is not matched by current practices, the NML case would prove to be an additional leverage for educational change.

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