

NEW MILLENNIUM LEARNERS: A PROJECT IN PROGRESS OPTIMISING LEARNING: IMPLICATIONS OF LEARNING SCIENCES RESEARCH

This paper offers an account of the preliminary findings accumulated during the first phase of the project, which focuses on the effects of technologies on learners. The main objective is to take stock of the existing empirical evidence and identifying areas that would benefit from further exploration in the current phase.

Introduction

The CERI Project entitled New Millennium Learners (NML) started in 2007 with the global aims of investigating the effects of digital technologies on school-age learners and providing some recommendations on the most appropriate institutional and policy responses from the education sector. Adopting a classical approach, the project comprises two different phases: the first phase explores the demand side, *i.e.* the changes, if any, experienced by learners. This phase is currently ongoing until the end of 2008. In the second phase, current and emerging educational responses will be reviewed.

The paper is divided into four main sections and two annexes. The first section offers an update of the evidence base presented previously in the first background paper on this project [EDU/CERI/CD/RD(2006)3].¹ The first issue presented in this section examines the speed at which digital technologies and services have become an integral part of the daily lives of children and teenagers across OECD countries and the extent to which their relationships with these technologies shape their activities, including how they manage social interactions and knowledge. The second and most important issue is how far the concept of NML can be applied to all OECD children and teenagers. No matter how attractive the label of NML might be, by no means should it 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.

The second section presents and discusses the main research findings in controversial areas such as the effects of technologies on *i)* cognitive skills development, *ii)* social values and lifestyles, and *iii)* educational performance. This section reveals how little is known and examines how empirical research has contributed more to highlighting the negative impacts of technology than to unveiling and documenting its positive sides. Accordingly, a plea for more empirical research as well as for more cumulative efforts is made.

The third section presents areas in the project that have not yet been addressed because the relevance of these areas has only recently emerged. In particular, it discusses the importance of incorporating the voices of NML into the development of the project from now on.

The final section presents some concluding remarks arising from these preliminary findings. In addition, the two annexes provide an update of the progress of the project from a managerial perspective, and the assessment and recommendations made by the Project's Advisory Committee.

1. An updated version of this background paper has been published recently (Pedró, 2007).

Are NML a case for education policy making?

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 readily available to them. 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, television emerged, digital technologies, and the services associated with them, convey something completely new: they modify not only the speed at which people deal with and manage information but also how they eventually transform it into knowledge. From a purely rational perspective this is a good starting point for wondering 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.

In this context, this section addresses two different issues which can give some ground to the NML case. The first issue concerns how readily children and young people adopt the new technology in contrast to the actual use of the same devices and services by educational institutions. The second addresses the concept of NML itself: whilst this concept effectively evokes the phenomenon of the impact of digital technologies on learners, does it also obscure the required policy focus on the differing effects of technologies on different profiles of young people and the urgency of developing adequate policy strategies to cope with the emerging divides.

Technology everywhere, except at school

Even accounting for some degree of variation in OECD countries, in general the speed at which technology penetrates children's and young people's lives mimics the rate of adoption at the home level, which runs very fast. According to the last PISA survey (2006), 86% of pupils aged 15 frequently² use 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 it is 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 the frequent use of a computer at home will become a universal feature of young people aged 15 in most OECD countries.³

Such an increase in use correlates with media preference as well. In a UK survey it was found that given a choice of six media, one-third of children aged 8 to 17 would choose the Internet as their only choice if they could not have any other, surpassing TV, telephone and radio (BBC Monitoring International Reports, 2002). However, in practice, the emergence of computers and the web, partly thanks to multitasking, has not reduced exposure to other media; on the contrary, computers increase the overall "screen" time by roughly 40% (Subrahmanyam, Kraut, Greenfield, & Gross, 2000). It is the Internet that increases the time spent with media (National Center for Education Statistics, 2004).

Alongside this overwhelming trend to the universalisation of access by teenagers, there are some indications that initial exposure to computers at very early age is also rising. Calvert, Ridout, Woolard, Barr, and Strouse (2004) report a constant linear increase in use among children aged 6 months to 6 years in the US. On average, toddlers start using computers at a parent's lap as early as at the age of 2.5 years and move to autonomous use approximately one year later. In the same context, already in 2006 children in the United States under the age of 6 almost universally lived in homes with television (98%), with a vast majority having computers (80%) and nearly half having videogame consoles as well (Rideout & Hammel,

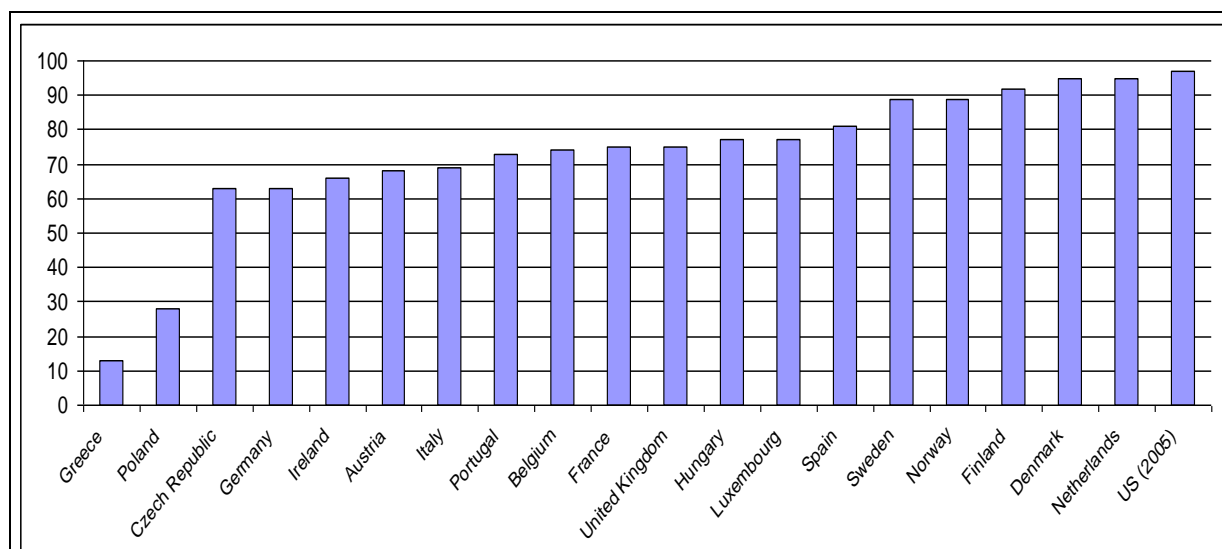
2. Defined in PISA as daily or a few times a week.

3. In fact, the presence of children in the home may be a primary reason for the adoption of computer technology in the household. As Drotner pointed out as early as in 2000, access to digital technologies is greater in homes with children than in those without (Drotner, 2000).

2006). More recently it has been found that 27% of 5 to 6-year-olds used a computer for 50 minutes on average on a typical day (Vandewater et al., 2007). The extent to which young children below the age of 6 are used to dealing with technologies⁴ shows clearly that they will be different from previous generations of children with respect to their comfort with this technology and the extent to which they use all forms of technology in their daily lives – maybe with the exception of their time spent in schools – and that this needs more focused research (Wartella & Robb, 2007) and improved methodologies and technical tools (National Research Council and Institute of Medicine, 2006).

The comparison with the situation in schools is inevitable. In the school sector, the rhythm of investments in technology, intended to facilitate its adoption, has generally been impressive in OECD countries. However, it is well known that the results in terms of real adoption fall short and do not match the initial expectations at all. The following two figures provide a clear indication of this gap 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 they have not used a computer at all in school during the past 12 months.

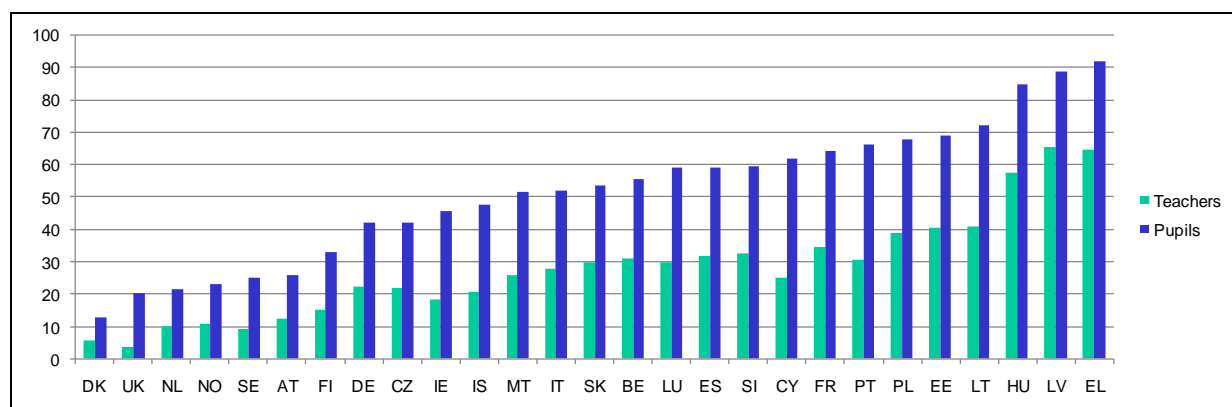
Table 1. Broadband in primary and secondary schools in some OECD countries (2006 or latest available year)



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

4. 82% of the 3- to 4-year-olds can turn on the television by themselves and a few less can put in a video or DVD by themselves (Vandewater et al., 2007).

Figure 1. 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.

On average, 50% of students in countries belonging to the European Union declare that they have not used a computer in the classroom in the past 12 months. Overall, the comparison of this information with what, in theory, could be done when one looks at the availability of technological infrastructure (as measured by the degree of broadband penetration) makes inevitable the discussion about the under-utilisation 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 inside the classroom or outside the school. And, thirdly, the different appreciations expressed by teachers and students must be noted as well. Teachers' declared lower levels of non-use of computers might well be related to the fact that they use the computers only for presentational purposes, which does not require pupils to carry out any activity on the computer. However, such a large disparity (which, in the better cases, reduces by half the degree of non-use by teachers as compared by that declared by pupils) also raises the issue of the difference between declared and actual teaching practices.

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 they are also in the world of adults, particularly at work – *except* when they are in classrooms, where even mobile phones are usually banned. Even worse, they can even see that an important technological infrastructure is in place, but under-used. A quite different question, 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 a policy concern

The second issue examined in this section provides a further indication of why NML should be considered a case for policy making. The main issues at stake here are that *i*) 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 *ii*) 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

Research has repeatedly pointed out the existence of a wide gender gap concerning technology. 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, and also appear to be more motivated in learning digital skills (Arnseth, Hatlevik, Kløvstad, Kristiansen, & Ottestad, 2007; Broos, 2006; OECD, 2003, 2007). Contrarily, girls seem to be dominant in the communicative fields of technology such as word processing, text messaging on cell phones, e-mail and blogging (Lenhart, 2007; OECD, 2007).

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 plays such a critical role, will, in the end, become mostly a male-designed, and therefore male-dominated, 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 technology related professions, which seems to be static or declining, even in cases of sustained inclusion efforts (Faulkner & Lie, 2007). If women are not participating equally in the design of new technologies and applications, the risk of developing a male-centred approach only increases further.

However, behind this discussion, lies the understanding that girls are somewhat falling behind. Meelissen and Drent make an interesting point when they highlight the fact that this discourse is only valid if boys' use is considered the norm and, as such, representative of the desired goals to reach (Gansmo, 2004; Gansmo, Nordli, & Sørensen, 2003; Lagesen, 2008; Meelissen, 2007; Sørensen, 2002). However, most of the research done so far is actually based on the assumption that girls are falling behind boys when it comes to technology, in terms of self attainment, attitudes, patterns of use and the like.

There is no general consensus yet on how to disentangle the gender issue in this domain, and whether targeted educational policies and practices should be put in place⁵. 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 powerful and attractive label is aimed to embrace both boys and girls, then the image must be made far more complex, ideally in such a way that gender-based dualisms are avoided.

The Mathew effect

Nowadays, the issue of access to technology seems to be nearly irrelevant in most OECD countries although not yet in all of them. On this basis, 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 socio-economic status.

The impact of socio-economic status requires that a refined approach be taken to the effects of technologies on learners. First, in each OECD country there is still a percentage of learners who have no access to digital technologies at all. Second, even in those cases where access is available, a second digital divide emerges: it is no longer about access, but about differences in use. Third, this second digital divide acts according to the pattern of the well-known Mathew effect and, if no political intervention is made, may *increase* existing socio-economic divides. Unfortunately, there is not much evidence that this issue is on the agenda of educational policy makers in OECD countries.

Although it can be claimed that there is an almost imminent horizon of universal access to technologies by 15 year olds, the fact is that, on average, 14% of all 15 year olds in all OECD countries do not have access at all to a computer connected to the internet. This figure is high enough to constitute 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.

5. 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.

Even in those countries where access to technology does not seem to be a matter of concern, due to 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 must be raised. Very little is known about this question from a comparative perspective, but from the existing limited evidence it emerges very clearly that, for instance, the use of the Internet, particularly the balance between leisure-oriented and learning-oriented activities, strongly depends on a number of family variables such as parents' educational level, experience and frequency of Internet use, which are, in turn, strongly connected to their socio-economic status (Mominó, Sigalés, & Meneses, 2008). A family's cultural capital is undoubtedly reflected also in parents' Internet practices and, therefore, also influences children's and youngsters' approaches to technologies (Pasquier, 2008). 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.

This last point raises the issue of the Mathew effect (Merton, 1968). It can be reasonably expected that those who are already in possession of 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 sound cultural capital will lag behind. In the long run, the existing differences between those who have and those who don't have 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 it easier to benefit from technologies, thanks to the cultural capital transferred to them, and they 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 in breaking the technology gap, as it was originally defined, in terms of access. However, a second digital gap is now emerging. To bridge it requires a new set of educational policies and practices, as they are related to technology practices associated with cultural capital.

Neither gender nor socio-economic status appear to be at the forefront of current educational research on technology, but they should be because both issues challenge the prevailing homogeneous and comfortable assumptions regarding the positive effects of technologies contained in the usual policy discourse. 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 the purpose of drawing attention to a fictitious image of the empowering effects of technologies on all children and youngsters equally.

The effects of technologies on learners

This section presents and discusses the main research findings⁶ in controversial areas such as the effects of technologies on cognitive skills development, social values and lifestyles, and educational performance, and reveals how little is known. It is worth noting that research in this domain has drawn strongly on the existing theoretical frameworks and empirical findings already used in the analysis of the

6. 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 Scandinavian 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.

effects of TV on children, either regarding the effects of violent content or the impact on children's cognitive development⁷.

The results of empirical research, particularly when considering meta-analyses, give the impression of a very scattered field, with only a few efforts made to accumulate knowledge in a way that becomes useful information for parents, educators and policy makers. It may well be that, on the whole, digital technologies are too recent, and their effects on learners too multi-faceted and interrelated – and hence difficult to untangle – to allow the research community to provide a coherent knowledge-base to the concerned stakeholders. Nevertheless, four messages emerge very clearly:

- First, that there is solid evidence regarding the effects of technology on cognitive skills development, particularly in areas related to visual-spatial skills and nonverbal forms of intelligence. Despite this, however, the most appealing domains, *i.e.*, those on which technology could have positive impact have not been documented by empirical research. Such areas as the abilities related to information processing, reflective and critical thinking, creativity and, in general, meta-cognitive skills are very often noted in this regard.
- Second, insofar as digital technologies are added to an already complex picture of media exposure, their effects on socialization are varied. On the one hand, it has been shown that time devoted to digital technologies adds to time devoted to other media and thus reduces time spent on family interaction or face-to-face peer interaction. But, on the other hand, time devoted to digital technologies gives rise to other forms of socialization in a third space, virtual by nature, which is less exposed to responsible adult supervision or counseling.
- Third, that there is enough empirical evidence to sustain the idea that playing with videogames which support violence or sexual stereotypes do have a negative effect on young people, particularly if the use is far from being moderate.
- And fourth, that there is an intrinsic difficulty when researching the effects of technology on educational performance. In practice, there is no conclusive evidence about the effects of technology 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, for which there is a great deal of empirical research done with inconclusive results – but also because the right methodological approach, which should involve large longitudinal studies, has not been put in place yet.

Cognitive skills development

Do computers and the Internet have any effects on children's cognitive skills and development overall? It is already clear from well documented research (Bracken & Lombard, 2004) that children can recall what they learn from a computer, especially if they are rewarded. However, the crucial question is how computers are affecting skill learning, cognition and the skills necessary for reasoning, problem solving, reading and creativity.

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, and preference for certain activities.

7. Because of its nature and purpose, the NML project does not focus on the eventual effects of technology on physical well-being, where research has already highlighted that children's extended computer use may be linked to an increased risk of obesity, seizures, and hand injuries (Subrahmanyam et al., 2000).

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 affects learners in broad terms, it improves the 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.

At least potentially, digital media contain features which provide opportunities for enhancing various cognitive skills. Throughout the years, their use in formal and informal settings 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; and how the use of computers and the Internet at home for playing games, searching for information, and communication affect cognitive skills.

However, it should be pointed out that most of the research addressing issues concerning technology and cognition has been qualitative in orientation, addressing issues to do with how technology 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 technology on cognition, something that would make the research less ecologically valid (Arnseth & Ludvigsen, 2006). In this respect, the most quoted research review, restricted only to empirical research, concluded that the most crucial question – whether technology enhances child development – has an affirmative answer (Koepl et al., 2001). Such a positive answer explains why this research review is so often quoted, despite the fact that a closer look at it reveals that the reviewers paid attention only to empirical research focusing on the positive impacts of technology on child development.⁸ Needless to say, research focused exclusively on the positive side of technology may be seen to reflect the interests of some interest and advocacy groups, as Atkinson *et al.* (2001) have already pointed out.⁹

With these limitations in mind, the following paragraphs present the existing evidence in areas where it can be said to be conclusive: namely, visual-spatial skills, the Flynn effect, memory skills, and to a lesser extent multitasking.

Visual-spatial skills

The ability to deal with two- and three-dimensional images, spatial visualization, and the skills needed 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.

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

8. As the authors openly state, “our search criteria focused on the literature examining the efficacy and effectiveness, rather than the negative outcomes of computer applications. As a result, the results were generally positive in nature because the “negative” findings were limited” (p. 32).

9. When they said that “there is always a possibility that advocacy plays a role in the aggregation and reporting of data” (p. 29).

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 most often quoted overview of the research on promoting spatial abilities through computer games (Souvignier, 2001) 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 visual-spatial skills can be improved by playing videogames, it is not conclusive about the degree of transferability of such an improvement.

Memory skills

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 6 000 4th graders in Germany.

Multitasking

It is well documented now (Foehr, 2006) that 63% of US young people aged 12 to 18 do multitask either most or some of the time while they are using a computer, and that 64% do multiple things at the same time on the computer. The migration of media into young people's bedrooms is likely responsible, in part, for media multitasking, along with the fact that the computer and the Internet are increasingly the preferred gateways to access a variety of media, including TV and music. However, it is probably too early to say anything of practical value drawing on existing research.

In spite of this, no research has focused specifically on the effects of media multitasking so far. Neurological research seems to suggest that brain capacity is finite and that attention to one task diminishes as another is introduced (Just *et al.*, 2001). Nevertheless, the way in which young people multitask when they are in front of a computer screen is somewhat different: they are not attempting to process non-complementary messages simultaneously, but rather are switching back and forth between different activities. Neurological research has identified the portion of the brain responsible for this kind of activity-switching (Wallis, 2006), but little is known about the effects of constant switching between media, even if all of them are supported by just one technological device, *i.e.* a computer. What is certain is that multitasking is a phenomenon that will not disappear –rather, contrarily, it will become mainstream.

The Flynn effect

Researchers claim that the exposure to the proliferation of imagery in media has contributed to the selective increases in nonverbal intelligence scores during the past century in industrialised countries, according to the so-called Flynn effect.¹⁰ For example, a comparison of average scores on the Raven

10. The Flynn effect is the rise of average Intelligence Quotient (IQ) test scores, an effect seen in most industrialized countries, although at greatly varying rates. It is named after James R. Flynn, who did much

Progressive Matrices test (nonverbal) among British adults of comparable ages in 1942 and 1992 showed significant increases for all age groups tested (Greenfield, 1998).

Flynn's current explanation (Flynn, 2007) is that environmental changes arising from modernization – such as more intellectually demanding work, greater use of technology and smaller families – have meant that people are far more used to manipulating abstract concepts such as hypotheses and categories than a century ago. Substantial portions of IQ tests deal with these abilities.¹¹ However, other researchers (Neisser, 1998) have found that the Flynn effect may be largely due to increased performance on nonverbal items, especially on items that draw on spatial visualisation. Hence the Flynn effect might also be due to the increased use of audiovisual media by children. Children's exposure to computer screens and, particularly, to videogames may have a similar long-term effect, individually and perhaps generationally, and there is already some research documenting it (Newcombe & Huttenlocher, 2000).

Limits of available evidence

The influence of technology use on reasoning capability and judgment has been shown to be relatively small, while there are many studies regarding the influence of technology use on abilities related to information processing, reflective and critical thinking, creativity and, in general, meta-cognitive skills. However, no research review has documented a positive effect yet on the basis of empirical research. And it may well be that this shows the need for a “neuroscience of children and media” intended to research the impact of digital media on children's brain development, a need that has only been expressed very recently (C.A. Anderson, 2007).

Most of the criticism in regard to assessing the impact of technology 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 extent 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

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.

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

to document it and promote awareness of its implications. This increase has been continuous and roughly linear from the earliest days of testing to the present.

11. Flynn gives as an example the following question: “What do a dog and a rabbit have in common?” A modern respondent might say they are both mammals (an abstract answer), whereas someone a century ago might say that you catch rabbits with dogs (a concrete answer).

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, and educational characteristics as well as environmental influences such as the values and preferences of parents and peers.

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

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. These are specifically popular among teenage girls. As a result, youngsters tend to project an image of isolation – they look as if they were concentrated in their own inner life – but, in fact, most of the time they are interacting socially with others while being continuously on-line or texting messages.

Despite the clearly increasing digital media use for social purposes, it is not immediately obvious how this affects inter-personal skills and social resources. On the one hand, 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 supplements the telephone and face-to-face visits, but rarely replaces the older modes of communication. On the other, uploading video clips on *YouTube* or participating in online games like *World of Warcraft* might indicate that the Internet also opens up opportunities for participation in global networks, thus extending the normal boundaries of social networks.

Nevertheless, it is clear that the time allotted to family interaction has been reduced. When families adopt yet another solitary medium into their home, time spent with the computer takes away from time spent with other family members. However, in the context of most OECD families, computers and the Internet are just another addition to an already complex media environment; if, as a result, family time is displaced, the computer is not the one to be blamed. Therefore, computer use can potentially have a negative impact on social interaction in the family (unless parents do not care about the amount of time spent at the computer), but, as a counterweight, it may increase feeling of belongingness with peers (Krcmar & Strizkakova, 2006).

The effects of videogames

Computer and video games are, worldwide, the fastest growing entertainment segment (DFC, 2004), with a market worth 35 billion USD worldwide in 2008. As a whole, already in 2000 they surpassed all Hollywood revenues (RocSearch, 2005). In 1993, the average US 14-year-old spent a maximum of 6 hours per week playing videogames, but in fact 12% of boys and 37% of girls did not play videogames at all (Funk, 1993). A decade later, in 2003, the average US 14-year-old spent on average 17 hours per week on

videogames, and almost 10% spent more than 30 hours per week (Sherry, de Souza, Greenberg, & Lachlan, 2003).¹²

Like any medium, videogames are a channel of communication whose effects vary widely with the content of the specific game in question. Experimental, longitudinal and meta-analytic data indicate that playing violent video games increases aggression, hostility and aggressive thoughts (C.A. Anderson, Gentile, & Buckley, 2007). Because research consistently shows that most popular video games are violent (Dill, Gentile, Richter, & Dill, 2005; Lachlan, Smith, & Tamborini, 2005) and because of the potential harm to children, youth and society of this negative influence, much video game research has focused on the effects of violent video games. Modeled after the extensive literature on television violence effects, the literature on the effects of violent video games shows a consistent link between violent video game play and aggression (C.A. Anderson et al., 2003).¹³

The debate about the effects of playing computer games with violent content has been heated again by recent findings, which tend to attract enormous media attention when they point to the negative effects of playing videogames. Spitzer (2007) stated that violent content influences brain processes and is related to the development of aggressive behaviour, which would eventually lead to increase in criminal events in future. Such findings replicate what an early meta-analysis on the research on violent videogames (C.A. Anderson & Bushman, 2001) found: exposure to violent videogames is positively associated with increased levels of aggression. And, in fact, if only those studies with the soundest methodological approaches were used, results showed even stronger effect sizes (C.A. Anderson, 2004). Moreover, effect sizes seem to have increased over time, with more current studies showing stronger effects, presumably due to the greater realism of today's games.

On the other hand, researchers have recently begun to focus attention on stereotypical portrayals of women and minorities in video games and the adverse effects of these characterizations (Brenick, Henning, Killen, O'Connor, & Collins, 2007). It is now clear that there is a positive association between violent videogame play and anti-women attitudes including attitudes supporting violence against women.¹⁴ A number of studies found that women are under-represented, stereotyped and objectified in video games. Some of this research indicates that minorities are also stereotyped in video games.¹⁵

Videogames convey interpretations of reality, social relations and events, but often in simplified and stereotyped form. Several theories explain how exposure to videogames, especially violent games, can lead

-
12. Gender differences are striking in this respect. Among children ages 2 to 7, boys are 25% more likely than girls to lay videogames on a regular basis, whereas male teenagers are 49% more likely to play than their female counterparts (Rideout, Vandewater, & Wartella, 2003).
 13. For example, Carnagey and Anderson (2005) found that when a car racing game rewarded players for violent acts, those players were more likely to attack an opponent than when the same game punished players for aggression. Konijn, Bijvank and Bushman (2007) found that adolescent boys who identified with aggressive characters in immersive, realistic games were most aggressive, going so far as to blast opponents with noise levels they believed would cause permanent hearing damage.
 14. For example, Dill et al. (2005) found that youth exposed to sexist images of video game characters were more likely to accept rape myths (such as the idea that women enjoy sexual force, that men should dominate women sexually and that women who say "no" are simply engaging in "token refusals") than youth exposed to images of professional men and women.
 15. For example, Dill et al. (2005) found that Middle Easterners were over-represented as targets of violence in video games. Burgess, Stermer, Burgess, Brown, Dill and Collins (in press) found that male African-American video game characters are stereotyped as athletes and "gangstas" or "thugs" who are more likely to use guns – particularly extreme guns – than characters of other races. Furthermore, most Asian women are represented as non-aggressive beauties and most Asian men (fully 75%) are shown using martial arts.

to imitative behaviour. The bestselling videogames do have a negative impact on social attitudes towards violence and sexual harassment by lowering the threshold of tolerance. However, it appears to be widely assumed that only on very rare occasions are players under the illusion that their behaviours in the game world as transferable to real world. At least, this seems to be the view shared by most parents, educators and, possibly, policy makers, who do not consider it a matter of serious concern that the videogame genre most preferred by children up to the age of 18 is action or combat (42%) (Rideout, Roberts, & Foehr, 2005), probably because they have not received a clear warning message from the research community.

Unfortunately, there is scarce evidence regarding the possible positive effects of videogames, probably because researchers are not interested in them, and media may not pay as much attention to such findings. However, existing evidence indicates that moderate game-playing does not significantly impact children's social skills either positively or negatively as studies often found no differences in the sociability and social interactions of computer games players *versus* non-players (Subrahmanyam et al., 2000). So, the issue at stake is what is considered to be moderate use, and what kind of adult supervision do videogames require.

Overall conclusion

Although the existing evidence does not offer conclusive answers to questions regarding the effects of different uses of technology 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 lessened or prevented. Despite the attempts of governments to limit the possible access of children to violent content, this can easily be circumvented with the help of siblings, friends, and even parents. It seems that control of children's and adolescents' use of digital media by parents is of primary importance; thus, parents need to be alerted about the dangers of the opportunities new technologies create. This could also be a subject of media education directed towards parents.

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

Educational performance

Analysing the question of something apparently as simple as the impact of technology on the quality of education does not seem to have produced 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 technology use and educational attainment, and both ways are presented below. In practice, however, there is no conclusive evidence about the effects of technology 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 to evaluate relationships as complex as those among technology access, frequency of use at school and out of school, and academic achievement.

Empirical experiments

Experiments can only attempt to determine how effective technologies 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 taught using an ICT-rich teaching methodology with the achievements of another group with similar characteristics being taught using traditional methods. The preferred subject for this type of analysis is usually maths.

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 formulation, there is insufficient evidence to affirm either the superiority or inferiority of technology-rich methodologies. This would seem to be the outcome of two systematic reviews of literature 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), and the other, 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 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.

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. 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 technology 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 defined well, therefore it is not surprising that agencies such as the *Center for Applied Research in Educational Technology* (CARET), *Futurelab* or *ITU*¹⁶ emerge whose basic role is to disseminate research results and convert them into advice and strategies to enable technology use to lead to improved educational attainment.

Correlation analyses

Studies of this sort attempt to demonstrate any 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.

16. 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 and Melinda Gates Foundation. FUTURELAB (www.futurelab.org.uk) is a not-for-profit organisation in the UK aiming at playing an interface role between research, innovation and practice in the domain of educational technology. ITU, which stands for National Network for IT and Competence in Education, (www.itu.no) is an academic unit at the University of Oslo (NO) intended to contribute to national knowledge building about digital education and digital skills.

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 relationship between the technology availability and use, on the one hand, and educational attainment, on the other. Examples of studies about technology use in teaching maths, to name but a few, include some that establish a positive correlation (M. 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.

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), while others conclude the complete opposite (Wenglinsky, 1998), including a comparative study of 31 different countries based on PISA data (Fuchs & Woessmann, 2004). More recent studies (Kuhlemeier & Hemker, 2007) seem to suggest that a closer look is required, putting far more emphasis on the applications and uses of computers than on the mere availability of technology.

The analysis of the PISA results (2003)¹⁷ has helped clarify the circumstances in 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 not linear but extremely complex. Consequently, if this is the case, it is hardly surprising that complexity is mistaken for inconsistency.

Indeed, the analysis of PISA reveals that there is a weak but generally positive relationship between the use of technology 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 technology access obtained below-average PISA results.
- *Previous experience*: the lower the experience in 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 the case 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.

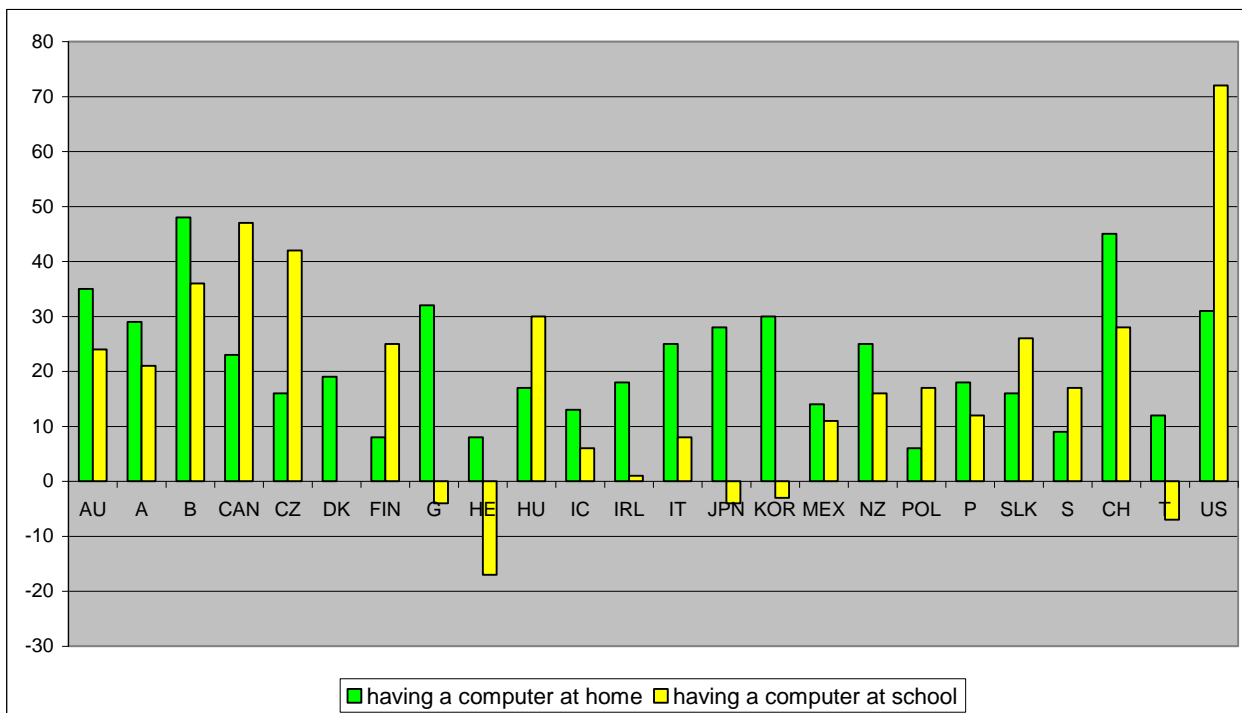
What is equally or more interesting than these correlations are the conclusions that can be drawn from technology use at home and educational attainment, also on the basis of the PISA database (2003). Probably the most important conclusion of all is that the correlation between home use and academic 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 the case that students using computers at home less often had below-average results.

17. An update based on 2006 PISA is currently under preparation in the context of the NML project.

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

Figure 2. 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).

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.

Overall conclusion

There is a risk of developing two policy discourses. The first one claims that the real educational benefits of using technologies are to be seen in domains such as team working, creativity, problem-solving and the like. The problem with this is that these domains are hardly assessed in national examinations. The second discourse focuses on what are the factors that really boost performance as measured in current national and international surveys. For the former, investing more in technology is a must; for the latter, there is not enough evidence.

In fact there is no conclusive evidence about the benefits of technology in school performance, but may be due to the fact that the research methodologies used so far are either weak or inappropriate,

because they do not ask the right question. For instance, despite the plethora of studies conducted on the effects of technology, there has been not any large-scale longitudinal study of technology impact in education. As Cox and Marshall (2007) have recently highlighted, there is a need for methodologically robust studies, based on large and varied samples, conducted over several years intended to provide unambiguous answers to questions such as:

- What impact have specific technology uses had on pupils?
- Does the way in which technology is implemented have a minor or major impact on pupils learning?
- Does the impact affect the surface or deep structure of pupils' thinking and acting?

Thus, the right question is not whether technologies are worth using or not, but rather how to use them to improve the quality and the results of education.

Emerging issues and future directions

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 emerged as a result of the work being carried out in other domains. 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 in regard to their expectations. Answers to these three issues would certainly contribute to a better understanding of the demand side of the NML.

Are student teachers NML?

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

- The absence of appropriate incentives to use technology in the classroom and, more generally, 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.

While the first is related to the configuration of education systems and, particularly, to career development in the teaching profession, the other two suggest clearly 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 a particularly good job of providing student teachers, not only with the vision, but, even more importantly, the required hands-on experience of learning with technology (Kleiner, Thomas, & 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 dealing 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 instils such disaffection into them.

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 supported 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?

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

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 are for 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 on 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, complete escape adult detection and responsible supervision.

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 also increasingly 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. Buckingham (2006), for instance, has suggested that the analytical framework of media literacy might be successfully applied in schools as a tool for developing consciousness and reflective

18. 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. The term was originally coined by Tim O'Reilly (2005).

practices when using Internet. Moreover, Jenkins *et al.* (2007) claim that an important goal of media education should be to encourage young people to become more reflective about the ethical choices they make as participants and communicators and the impact they might have upon others

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. In this perspective, Jenkins *et al.* (2007) highlight the need to insure that every child has been socialized into the emerging ethical standards which should shape their practices as media makers and as participants within online communities. New participatory culture places new emphasis upon familiar skills as well as requires teachers to pay greater attention to the social skills and cultural competencies that are emerging in response to changes in the media landscape. However, too little is known about this and more empirical research should be conducted.

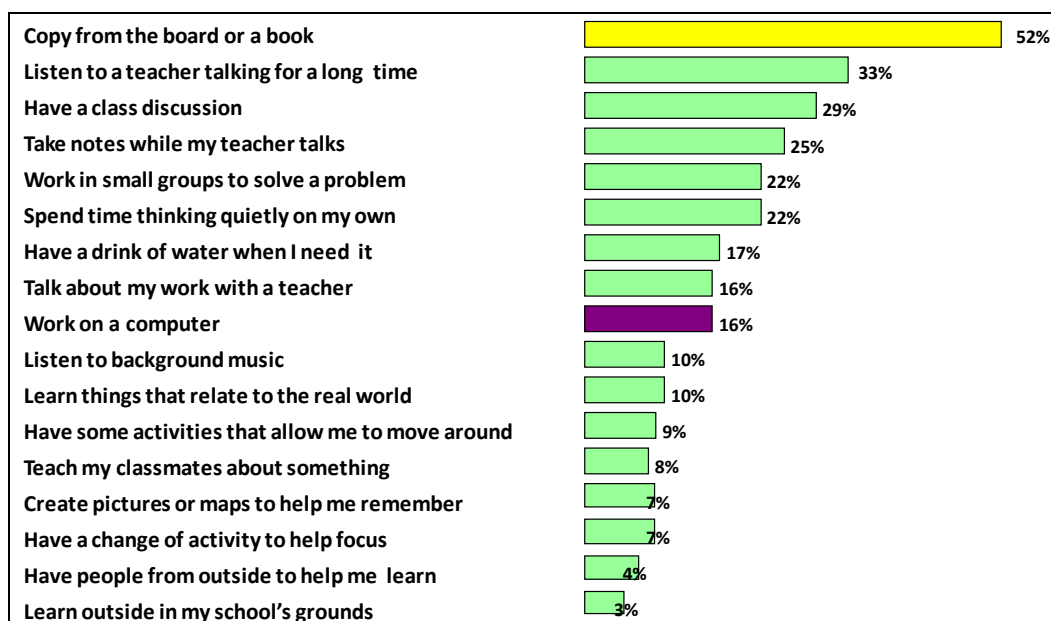
Bringing in learners' voices

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

The next two figures provide an example of the kind of relevant information that could eventually be gathered if the learners' voices were taken into account. Both figures are 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 3. Most common classroom activities according to English pupils aged 15

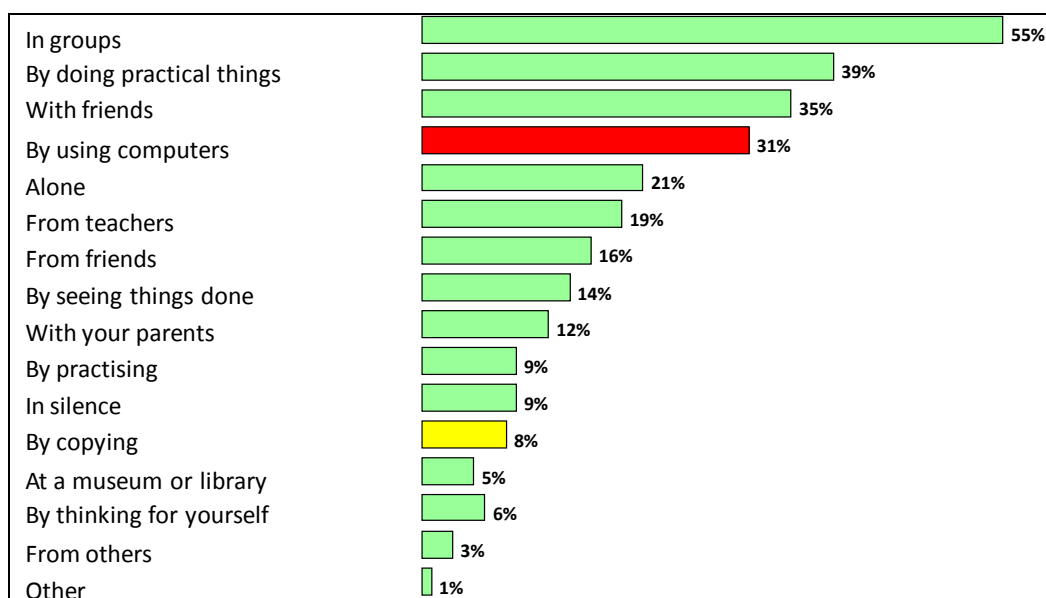
Q: Which three of the following do you do most often in class?



Source: Ipsos Mori (2007).

Figure 4. 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).

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 not long far from matching learners' expectations, but 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 effort in identifying and revealing learners' (boys and girls) perceptions of desirable changes in education. If research points in the same direction and this is not matched by current practices, the NML case would prove to be an additional leverage for educational change.

Concluding remarks

A first remark has to do with the concept of NML, or more precisely, with the issue of adopting such a title to cover such a complex research field as that focusing on the effects of technology on learners. NML may be a good brand to suggest that there is an urgent need to know more about these effects, but it would be misused if it only served to draw attention to a fictitious image of empowering effects of technologies on all children and youngsters equally. NML works well as a recognisable title for a project, but that is all. The generational approach adopted by most analysts and essay writers cannot be sustained empirically. Contrarily, there is enough evidence to claim that 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. Neither gender nor socio-economic status seem to be at the forefront of current educational research on technology. But they should be, as both issues challenge the prevailing homogeneous and comfortable assumptions regarding the positive effects of technologies that the common policy discourse usually contains.

The second remark is that research in this field seems to still be in its infancy and much effort is needed to accumulate more knowledge. There is a pressing need for more systematic research across the broad range of topics discussed here to better understand the effects of technology on learners. Up to now, there seems to be an important divide among researchers dealing with these issues. As it has been phrased by Livingstone (2007), some researchers anchor their investigation by reference to an issue which is considered problematic in nature, such as violence or lack of attention, and then ask to what extent technologies are to blame. Their response comes after rigorous testing intended to identify causes. A second group of researchers begin with a critique of this approach for being too focused on the negative sides of the effects of technologies, and then proceed by way of describing how children enjoy technologies and what they believe that children gain from them. Although it is likely the truth may lie somewhere in the middle, unfortunately this second approach has failed to bring any conclusive empirical findings so far.

REFERENCES

- Anderson, C. A. (2004). An update on the effects of playing violent video games. *Journal of Adolescence*, 27(1), 113-122.
- Anderson, C. A. (2007). A neuroscience of children and media? *Journal of Children and Media*, 1(1), 77-85.
- Anderson, C. A., Berkowitz, L., Donnerstein, E., Huesmann, L. R., Johnson, J. D., Linz, D., et al. (2003). The influence of media violence on youth. *Psychological Science in the Public Interest*, 4(3), 81-110.
- Anderson, C. A., & Bushman, B. J. (2001). Effects of violent video games on aggressive behavior, aggressive cognition, aggressive affect, physiological arousal, and prosocial behavior: A metaanalytic review of the scientific literature. *Psychological Science in the Public Interest*(12), 353-359.
- Anderson, C. A., Gentile, D. A., & Buckley, K. E. (2007). *Violent Video Game Effects on Children and Adolescents. Theory, Research, and Public Policy*. New York: Oxford University Press.
- Angrist, J., & Lavy, V. (2002). New evidence on classroom computers and pupil learning. *The Economic Journal*(112), 735-765.
- Arnseth, H. C., Hatlevik, K., Kløvstad, V., Kristiansen, T., & Ottestad, G. (2007). *ITU Monitor 2007. Skolens digitale tilstand*. Oslo: Forsknings- og kompetansenettverk for IT i utdanning, ITU.
- Arnseth, H. C., & Ludvigsen, S. R. (2006). Approaching institutional context: Systemic versus dialogic research in CSCL. *International Journal of Computer-Supported Collaborative Learning*(1), 167-185.
- Atkinson, N. L., Silsby, J., Gold, R. S., Koepl, P. T., Chokshi, A. N., & Gutierrez, L. S. (2001). *Technology and Child Development, Part I: a Ten-Year Review of Reviews*. Decatur, GA: The Center for Child Well-being.
- Bracken, C. C., & Lombard, M. (2004). Social presence and children: Praise, intrinsic motivation, and learning with computers. *Journal of Communication*(54), 22-37.
- Brenick, A., Henning, A., Killen, M., O'Connor, A., & Collins, M. (2007). Social reasoning about stereotypic images in video games: Unfair, legitimate, or "just entertainment"? *Youth and Society*(38), 395-419.
- Broos, A. R. K. (2006). The digital divide in the playstation generation: Self efficiency, locus of control and ICT adoption among adolescents. *POETICS*(34), 306-317.
- Buckingham, D. (2006). Defining digital literacy. What do young people need to know about digital media? *Digital kompetanse. Nordic Journal of Digital Literacy*, 1(4), 263-276.

- Burgess, M., Stermer, P., Burgess, S., Brown, B. P., Dill, K. E., & Collins, M. A. (in press). Playing with Prejudice: The Prevalence and Consequences of Racial Stereotypes in Videogames. *Personality and Social Psychology Bulletin*.
- Calvert, S. L., Rideout, V. J., Woolard, J. L., Barr, R. F., & Strouse, G. A. (2004). Age, ethnicity, and socioeconomic patterns in early computer use: a national survey. *American Behavioural Scientist*, 48(5), 590-607.
- Carnagey, N. L., & Anderson, C. A. (2005). The effects of reward and punishment in violent video games on aggressive affect, cognition and behavior. *Psychological Science in the Public Interest*(16), 882-889.
- Cox, M., Abbott, C., Webb, M., Blakely, B., Beauchamp, T., & Rhodes, V. (2003). *ICT and attainment: A review of the research literature*. Coventry: British Educational Communications and Technology Agency.
- Cox, M. J., & Marshall, G. (2007). Effects of ICT: Do we know what we should know? *Education and Information Technology*(12), 59-70.
- Dill, K. E., Gentile, D. A., Richter, W. A., & Dill, J. C. (2005). Violence, sex, race and age in popular video games: A content analysis. In E. Cole & J. H. Daniel (Eds.), *Featuring females: Feminist analyses of the media*. Washington, DC: American Psychological Association.
- Drotner, K. (2000). Difference and diversity: Trends in young Danes' media use. *Media, Culture and Society*, 22(2), 149-166.
- Faulkner, W., & Lie, M. (2007). Gender in the Information Society. Strategies of Inclusion. *Gender, Technology and Development*, 11(2), 157-177.
- Flynn, J. R. (2007). *What is Intelligence?: Beyond the Flynn Effect*. Cambridge: Cambridge University Press.
- Foehr, U. G. (2006). *Media multitasking among American youth: prevalence, predictors and pairings*. Menlo Park, CA: The Henry J. Kaiser Family Foundation.
- Fuchs, T., & Woessmann, L. (2004). *Computers and student learning: Bivariate and multivariate evidence on the availability and use of computers at home and school*. Munich, Germany: Center for Economic Studies.
- Funk, J. B. (1993). Reevaluating the impact of videogames. *Clinical Pediatrics*(32), 86-90.
- Gansmo, H. J. (2004). *Towards a happy ending for girls and computing?* Trondheim: Department of Interdisciplinary Studies of Culture, Faculty of Arts, Norwegian University of Science and Technology.
- Gansmo, H. J., Nordli, H., & Sørensen, K. H. (2003). *The gender game : a study of Norwegian computer game designers*. Trondheim: Senter for teknologi og samfunn, Norges teknisk-naturvitenskapelige universitet.
- Greenfield, P. M. (1998). The cultural evolution of IQ. In U. Neisser (Ed.), *The raising curve: Long-term gains in IQ and related measures*. Washington, DC: American Psychological Association.

- Harrison, C., Comber, C., Fisher, T., Haw, K., Lewin, C., Lunzer, E., et al. (2003). *ImpaCT2: The impact of information and communication technologies on student learning and achievement*. London: DfES.
- Infodev. (2005). *Knowledge Maps: ICTs in Education. What do we know about the effective uses of information and communication technologies in education in developing countries?* Washington, DC: The International Bank for Reconstruction and Development / The World Bank.
- Jenkins, H., Purushotma, R., Robinson, A. J., Weigel, M., & Clinton, C. (2007). Confronting the Challenges of Participatory Culture: Media Education for the 21st Century. *Digital Kompetanse. Nordic Journal of Digital Literacy*, 2(1).
- Just, M. A., Carpenter, P. A., Keller, T. A., Emery, L., Zajac, H., & Thulborn, K. R. (2001). Interdependence of Nonoverlapping Cortical systems in Dual Cognitive Tasks. *Neuroimage*, 14(2), 417-426.
- Kleiner, B., Thomas, N., & Lewis, L. (2007). *Educational Technology in Teacher Education Programs for Initial Licensure (NCES 2008-040)*. Washington, DC: National Center for Education Statistics, Institute of Education Sciences, US Department of Education.
- Koepl, P. T., Atkinson, N. L., Gold, R. S., Silsby, J., Chokshi, A. N., & Gutierrez, L. S. (2001). *Technology and Child Development, Part II: Lessons from Empirical Research*. Decatur, GA: The Center for Child Well-being.
- Konijn, E. A., Bijvank, M. N., & Bushman, B. J. (2007). I wish I were a warrior: The role of wishful identification in effects of violent video games on aggression in adolescent boys. *Developmental Psychology*(43), 1038-1044.
- Kozma, R. B. (2006). Monitoring and Evaluation of ICT for Education Impact: A Review. In D. Wagner, R. Day, T. James, R. Kozma, J. Miller & T. Unwin (Eds.), *Monitoring and Evaluation of ICT in Education Projects. A Handbook for Developing Countries*. Washington, DC: The International Bank for Reconstruction and Development / The World Bank.
- Krcmar, M., & Strizkakova, Y. (2006). Computer-Mediated Technology and Children. In C. A. Lin & D. J. Atkin (Eds.), *Communication Technology and Social Change: Theory and Implications* (pp. 59-76). New York: Routledge.
- Kuhlemeier, H., & Hemker, B. (2007). The impact of computer use at home on students' Internet skills. *Computers & Education*(49), 460-480.
- Kulik, J. A. (2003). *The effects of using instructional technology in elementary and secondary schools: What controlled evaluation studies say*. Arlington, VA: SRI International.
- Lachlan, K. A., Smith, S. L., & Tamborini, R. (2005). Models for aggressive behavior: The attributes of violent characters in popular video games. *Communication Studies*(56), 313-329.
- Lagesen, V. A. (2008). A Cyperfeminsit Utopia? Perceptions of Gender and Computer Science among Malaysian Women Computer ... *Science, Technology & Human Values*, 33(1), 5-27.

- Lenhart, A., Madden, M., Rankin Macgill, A. & A. Smith. (2007). *Teens and Social Media . The use of social media gains a greater foothold in teen life as they embrace the conversational nature of interactive online media.* . Washington DC, USA: Pew Internet & American Life Project.
- Meelissen, M. R. M. D., M. (2007). Gender differences in computer attitudes: does the school matter? *Computers in Human Behaviour.*
- Merton, R. K. (1968). The Matthew Effect in Science. *Science* 159 (3810), 56-63.
- Mominó, J. M., Sigalés, C., & Meneses, J. (2008). *La escuela en la sociedad red. Internet en la educación primaria y secundaria.* Barcelona: Ariel.
- Möble, T., Kleimann, M., Rehbein, F., & Pfeiffer, C. (2006). Mediennutzung, Schulerfolg, Jugendgewalt und die Krise der Jungen. *Zeitschrift für Jugendkriminalrecht und Jugendhilfe*(3), 295-309.
- National Center for Education Statistics. (2004). *Computer and Internet use. Supplement to 2001 Current Population Survey.* Washington, DC: National Center for Education Statistics, Institute of Education Sciences, US Department of Education.
- National Center for Educational Statistics. (2001). *The nation's report card: Mathematics 2000.* Washington, D.C.: National Center for Educational Statistics.
- National Research Council and Institute of Medicine. (2006). *Studying media effects on children and youth: Improving methods and measures.* Washington, DC: National Academies Press.
- Neisser, U. (1998). *The raising curve: Long-term gains in IQ and related measures.* Washington, DC: American Psychological Association.
- Newcombe, N. S., & Huttenlocher, J. (2000). *Making Space: The Development of Spatial Representation and Reasoning.* Boston, MA: MIT Press.
- O'Reilly, T. (2005). What Is Web 2.0. Retrieved 2006-08-06, from <http://www.oreillynet.com/pub/a/oreilly/tim/news/2005/09/30/what-is-web-20.html>
- OECD. (2003). *The PISA 2003 assessment framework : mathematics, reading, science and problem solving knowledge and skills.* [Paris]: OECD.
- OECD. (2007). *PISA 2006: Science Competencies for Tomorrow's World.* Paris: OECD.
- Pasquier, D. (2008). From parental control to peer pressure: cultural transmission and conformism. In S. Livingstone & K. Drotner (Eds.), *International handbook of children, media and culture* (pp. 448-459). London: Sage.
- Pedró, F. (2007). The New Millennium Learners: Challenging our Views on Digital Technologies and Learning. *Nordic Journal of Digital Literacy*, 2(4), 244-264.
- Pelgrum, W., & Plomp, T. (2002). Indicators of ICT in mathematics: Status and covariation with achievement measures. In A. Beaton & D. Robitaille (Eds.), *Secondary analysis of the TIMSS data.* Dordrecht, Netherlands: Kluwer Academic Press.

- Ravitz, J., Mergendoller, J., & Rush, W. (2003). *What's school got to do with it? Cautionary tales about correlations between student computer use and academic achievement*. Paper presented at the AERA, Chicago.
- Rideout, V. J., & Hammel, E. (2006). *The Media Family: Electronic Media in the Lives of infants, Toddlers, Preschoolers and their Parents*. Menlo Park, CA: Henry J. Kaiser Family Foundation.
- Rideout, V. J., Roberts, D. F., & Foehr, U. G. (2005). *Generation M: Media in the lives of 8-18 year-olds*. Menlo Park: The Henry J. Kaiser Family Foundation.
- Rideout, V. J., Vandewater, E. A., & Wartella, E. A. (2003). *Zero to Six. Electronic Media in the Lives of Infants, Toddlers and Preschoolers*. Menlo Park: The Henry J. Kaiser Family Foundation.
- RocSearch. (2005). *Videogame Industry*. London: RocSearch.
- Sherry, J. L., de Souza, R., Greenberg, B. S., & Lachlan, K. (2003). *Why do adolescents play videogames? Developmental stages predicts videogame uses and gratifications, game preference, and amount of time spent in play*. Paper presented at the Annual Convention of the International Communication Association.
- Sørensen, K. H., and James Stewart (Ed.). (2002). *Digital Divides and Inclusion Measures. A review of Literature and Statistical Trends on Gender and ICT* (Vol. 59 - 2002). Trondheim/ Edinburgh: Dept. of Interdisciplinary Cultural Studies, Norwegian University of Technology and Science.
- Souvignier, E. (2001). Training räumlicher Fähigkeiten. In K. Klauer (Ed.), *Handbuch Kognitives Training* (pp. 293-319). Göttingen: Hogrefe.
- Spitzer, M. (2007). *Vorsicht Bildschirm! Elektronische Medien, Gehirnentwicklung, Gesundheit und Gesellschaft*. München: dtv.
- Subrahmanyam, K., Kraut, R. E., Greenfield, A. M., & Gross, P. M. (2000). The impact of home computer use on children's activities and development. *Children and Computer Technology*(10), 123-144.
- Ungerleider, C., & Burns, T. (2003). *A Systematic Review of the Effectiveness and Efficiency of Networked ICT in Education. A State of the Art Report to the Council of Ministers of Education Canada and Industry Canada*. Unpublished manuscript.
- Vandewater, E. A., Rideout, V. J., Wartella, E., Huang, X., Lee, J. H., & Shim, M. (2007). Digital Childhood: Electronic Media and Technology Use Among Infants, Toddlers, and Preschoolers. *Pediatrics*, 119(5), 1006-1015.
- Wallis, C. (2006). The Multitasking Generation: they're emailing, IMing and downloading while writing the history essay. What is all that digital juggling doing to kids' brains and their family life? *Time*(167), 48-55.
- Wartella, E., & Robb, M. (2007). Young children, new media. *Journal of Children and Media*, 1(1), 35-44.
- Wenglinsky, H. (1998). *Does it compute? The relationship between educational and student achievement in mathematics*. Princeton: ETS.