

OECD Background Paper for OECD-KERIS Expert Meeting
INFORMATION AND COMMUNICATION TECHNOLOGIES AND
EDUCATIONAL PERFORMANCE

Magdalena Claro
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1. Introduction

For at least a decade, in many countries, considerable investment has been placed in Information and Communication Technologies for education, and today concrete results or impacts of these investments are required. In order to find evidence in this area, an important amount of research has focused on the use of ICT in the classroom, where teachers' ability to integrate these technologies into their teaching practices has been the main concern and learning is expected as a consequence of ICT curricular integration. In other words, the focus has been placed in schools and on teachers as the agents of change regarding ICT learning. The OECD's Centre for Educational Research and Innovation (CERI) New Millennium Learners (NML) Activity focuses instead on the new generation of students and what they might be revealing in terms of expected, but also unexpected, impacts of ICT. It aims, on the one hand, to conceptualise and analyse from a comparative perspective the effects of digital technologies on younger generations' cognitive development, values and lifestyles, and educational expectations, and on the other hand, to examine the educational responses to the emergence of this new phenomenon. The goal is to provide policy-makers, researchers and educators with valuable insights on what could be the most suitable policies and practices to deal with this new generation of learners in light of the needs and requirements of the knowledge society.

In this context, one of the objectives is to synthesize research on issues related to the conceptualization of NML and its social and educational implications from a multidisciplinary perspective. In other words, the interest here is to look at the NML from the demand side, thus looking at the main areas of concern resulting from the impact of the use of digital devices and services. Within this objective, the present paper seeks to understand what research says regarding new generations learning with ICT inside and outside the classroom. It particularly seeks two goals:

1. To synthesize the most relevant evidence and interpretations regarding the learning impacts of ICT in younger generations in four areas:
 - a. In-school use of ICT and impacts on school subject learning
 - b. In-school use of ICT and other learning outcomes
 - c. Out-of-school use of ICT and school subject learning
 - d. Out-of-school use of ICT and other learning outcomes

2. To provide orientations for future ICT and education policies that might be relevant in the context of the New Millennium Learners Activity.

2. Evidence on the learning impacts of ICT in younger generations

2.1. In-school use of ICT and impacts on school subjects learning

In general, national educational policies have introduced ICT in schools with the expectation that teachers will integrate them into the curriculum and by doing this will reinforce and improve students' learning in traditional subject areas, such as math, language or sciences. The research measuring these effects is most commonly based on a simple model, where a causal relationship between ICT use and students' attainment, as measured in traditional standardized tests (i.e. based on subject areas and content-knowledge), is assumed.

From a general perspective research in this regard has not been able to provide conclusive statements about positive or negative effects. On the contrary, findings are most often inconsistent between studies or difficult to generalize (i.e. they are commonly country based or developed under very specific conditions, such as in pilot projects or case studies). Additionally, there are very few experimental studies that allow for empirically sound conclusions related to causality between ICT and students' performance (Balanksat, Blamire & Kefala 2006; Kozma, 2006; Burns & Ungerleider, 2003; McFarlane et.al. 2000; Cuban, 1998)

Where evidence seems to converge, though, is in signaling a non-linear and complex relationship between ICT and learning. A major systematic review of European ICT impact studies (Balanksat, Blamire & Kefala, 2006) revealed as the only common finding that ICT has a positive impact on educational performance in primary schools, particularly in the home language (i.e. English) and science. Instead, this and other studies reviews (Trucano, 2005; Kulik, 2003) have found more evidence in relation to certain *school conditions* and *types of uses* that favor better results.

The results of the 2003 Programme for International Student Assessment of the OECD also point to a non-linear relationship between ICT use and educational attainment¹. The analysis of this data reveals a generally positive relationship between these two variables, but also provides a number of particular correlations that add complexity to this general conclusion (Pedró & Benavides, 2006: 23). These are:

1. Access: most students who have limited ICT access obtained below-average PISA results.
2. 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 math exercises.
3. 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.
4. 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 the more confident students.

¹ The PISA findings must be considered with caution in this section, because as it will be argued in section 2.2, this international assessment aims to measure subject-related knowledge as people's ability to apply knowledge and skills more than the extent to which they have mastered curricular knowledge.

In another analysis to PISA (2003) data, Fuchs & Woessman (2004) conclude that *access* to ICT at school and at home on its own does not show a positive impact on students' educational performance. They find that, although bivariate results suggest that there is a positive relationship in both cases, once family and school background are held constant, computer availability at home shows a strong statistically significant negative relationship to math and reading performance and that computer availability at school is unrelated to performance (p.14). Something different appears when ICT *use* is analyzed. They find that when computers are used at home as a communicational and educational device, a positive relationship appears with student performance. On the other hand, as said above, students who *never* use computers or the Internet at school show lower performance than students who *sometimes* use these technologies at school. Students that use them *several times a week* (i.e. more intensive users) perform even lower. (p.2)

The lack of clear evidence on the direct learning impact of ICT in school subjects has been explained in different ways by educational researchers and experts. The most important positions are the following:

1. When it comes to ICT it is very difficult to relate improvements in school achievement to a single cause. As Angela McFarlane et.al. (2000) state, "The problem is analogous to that of asking whether books are having an impact on learning: books are a medium for transmitting information, they cover a vast range of content, structure and genres, and they can be used in infinite ways." (p.9) In other words, ICT is not a homogeneous tool, and therefore some uses have proven to be more beneficial for certain school subjects than others. For example, uses of ICT for simulations and modeling have shown to be effective in learning science and math, while word processing and communication software (e-mail) have proven to be helpful in the development of student language and communication skills (Kulik, 2003; Trucano, 2005). Therefore, given the variety of ICT functionalities and applications, it is important to study impacts on the user considering different forms of ICT and models of use.
2. As stated before, study reviews conclude that learning with ICT in the classroom happens only when a number of school and pedagogical conditions are met. Among the most important are:
 - a. Good ICT equipment in schools and fertile ground in schools to make efficient use of ICT (Machin et.al, 2006).
 - b. Teachers with student-centered or constructivist philosophies (Becker, 2000).
 - c. Integration into the curriculum (Becta, 2005).
 - d. Quality of leadership and teaching (Becta, 2005, OECD 2005)
 - e. Presence of interactive technology in schools, such as whiteboards (Higgins, 2005).
 - f. Clear definition of goals for the use of ICT (Trucano, 2005).

3. ICT impacts learning outcomes indirectly. A consistent finding in this direction is the positive relationship between ICT and students' and teachers' motivation and concentration in class (McFarlane, 2000; Trucano, 2005; OECD, 2005; Blanksat, Blamire & Kefala, 2006; Becta 2006). This finding emerges from qualitative surveys that ask teachers and students their opinion about the benefits of using ICT at schools or directly if they see an effect over students' motivation. For example, 86% of teachers in Europe stated that pupils are more motivated and attentive when computers and the Internet are used in class (Empirica, 2006). Additionally, certain technologies are showing to be relatively more engaging and motivating for students than others. This is the case, for example, with interactive technologies such as multimedia or interactive whiteboards particularly for primary pupils (Higgins, 2006; European Schoolnet, 2004).
4. As technologies adapt to real educational needs, offering work tools and digital appliances specifically for education, ICT will be more appropriately used with the desired learning results (Means, 2000). Among these technologies, interactive whiteboards and laptops, provided on a one-to-one basis, have been supported.

With regard to laptops, it is argued that ubiquitous or one-to-one computing environments may enhance learning because they provide all students and teachers continuous access to digital pedagogical resources within the dynamics of the same classroom, something that computer labs outside the classroom do not allow.

There have been numerous efforts to do this in developed countries, particularly in the United States, and now in developing countries through Negroponte's *One Laptop Per Child's "\$100 laptop"* initiative (<http://laptop.org/vision/mission/>) Some lessons have been learned as to the essential conditions needed to successfully implement a laptop initiative, such as professional development for teachers and administrators and ongoing program monitoring and evaluation (Bonifaz & Zucker, 2004). However, there are still many areas that still need to be studied about laptop programs, among them, their real impact on students' learning. (Zucker & McGhee, 2005)

Research on Whiteboards on the other hand has revealed a clear enthusiasm for this technology by teachers and pupils, and an embedded use of this technology in the teaching of literacy and mathematics (Higgins, 2005). Among the characteristics that have been found favorable to teaching and learning in the classroom setting are their flexibility, versatility, efficiency, interactivity and multimedia and multimodal presentation. Nevertheless, as with laptops, the learning results of the use of this technology, remains unclear.

5. Finally, there are more skeptical views in relation to the positive impact of ICT on learning, such as that of Larry Cuban (2002) or Todd Oppenheimer (2003). For both authors the evidence available is proof enough that improvement of learning outcomes will not come –or only marginally-- from the presence of technology in the classroom. Instead, they believe that the

expected outcomes will only come from giving back to the teacher the central role it used to have in the classroom. Teachers are the ones who make a significant difference in learning. Cuban specifically advocates for the promotion of respect for teacher's expertise and their incorporation in decision-making processes. Oppenheimer claims that in modern societies schools' role, and particularly teachers' role, is to protect youngsters and offer them guidance. He acknowledges the useful role of certain technological applications for some subject areas or pedagogical activities, but these advantages are limited. In the end he says, technology advocates forget a central fact: "At its core, education is a people process. Yes, youngsters need tools, but most of all they need people." (p.395)

Summary and conclusions

The question regarding the direct impact of ICT in school subjects learning has not found a satisfactory answer. Evidence is scarce, inconsistent and does not allow for generalizations. Many studies converge in that the relationship between these two variables is mediated by other factors and hides more complex relationships than expected. These factors could be classified as 'endogenous to ICT' (i.e. directly related to the nature of use of these technologies) and 'exogenous to ICT' (i.e. related to the school and pedagogical conditions in which ICT are used). Among the endogenous factors found in this review are access, types of use, experience in use, frequency of use and confidence level. Among the exogenous factors found are teachers' pedagogical philosophy, schools' and teachers' integration into the curriculum and quality of leadership and teaching. Finally, there are several interpretations that aim to explain the lack of consistent evidence on the impact of ICT on curricular learning. Those summarized here are the need to revise the methodological approach to measuring these results; the need to develop adequate school and pedagogical conditions; the need to look at the impact of ICT on indirect variables affecting learning, such as motivation; the need for technology to adapt to the real needs of teachers and students in the classroom; and the need to focus on teachers instead of ICT as the central agents of learning improvement in the classroom.

2.2. In-school use of ICT and other learning outcomes

In the previous section, we presented different explanations that educational researchers and experts have given to the lack of sound evidence on learning results as measured in standardized tests. Although different in nature and scope, they all intended to explain the relationship between ICT and learning based on a traditional concept of school learning, that is, as curricular learning. But for some experts this phenomenon might be pointing to a different direction. They claim that young generations might be learning new things through the use of ICT, and, therefore, standardized assessments may not be the adequate tools to measure the impact of these technologies. As we briefly mentioned before, these tests are most commonly designed to measure the level of mastery of factual knowledge in subject areas. Instead, these specialists argue that ICT seem to be more influential in the development of what they call "21st Century Skills," which mainly include higher-order thinking skills (i.e. problem-solving; critical thinking; information-handling or

information-processing), independent learning, and team-work (McFarlane *et.al.* 2000; McFarlane, 2001; Cox, 1997; Bonnet *et.al.*1999). Furthermore, they claim that these skills may have an impact on traditional learning and at the same time become a desirable outcome in the context of modern societies where an individual's capacity to advance their knowledge and skills throughout their lives, and produce new knowledge in flexible contexts, are at the basis of economic and social development.

Although there is not much evidence in these areas of learning, there are some findings that confirm the ability of ICT to encourage independent learning and team-work. For example, Ramboll Management (2006) found that ICT allows for greater differentiation (especially in primary schools), with programs tailored to individual pupils' needs. On the other hand, they saw that when ICT is used for project work, collaboration between students is greater. Additionally, ITU (2004) found that students assume greater responsibility for their own learning when they use ICT and that ICT offers learners assignments more suited to their individual needs and makes it easier to organize their own learning. Finally, some other studies show that these skills are more likely to be acquired when used in conjunction with student-centered pedagogy (Kozma, 2006).

As to higher-order thinking skills, there are some findings such as higher-level conceptualization and better problem-solving (Mc Farlane *et.al.*, 2000), but still there are not many adequate assessment techniques to measure these new forms of learning. One important effort in this direction is OECD's Programme for International Student Assessment (PISA) mentioned above. This instrument, that includes a questionnaire about computer use, seeks to measure "how well young adults, at age 15 and therefore approaching the end of compulsory schooling, are prepared to meet the challenges of today's knowledge societies." It focuses on young people's ability to use their knowledge and skills to meet real-life challenges, rather than on the extent to which they have mastered a specific school curriculum (OECD, 2004: 20). Within the topic of our concern, this study has two important features: (a) an innovative "literacy" concept related with "the capacity of students to apply knowledge and skills in key subject areas and to analyze, reason and communicate effectively as they pose, solve and interpret problems in a variety of situations" (p.20) and its relevance to lifelong learning, "which does not limit PISA to assessing students' curricular and cross-curricular competencies but also asks them to report on their own motivation to learn, their beliefs about themselves and their learning strategies" (p.20).

Advocates of this approach promote a change in the goals and objectives of national curricula themselves, where it is more important what students can do with what they learn at school, than whether they can reproduce what they have learned. In this sense it is claimed that new skills related to lifelong learning should be included (OECD, 2006; Balanksat, Blamire & Kefala, 2006; Voogt & Pelgrum, 2005; McFarlane, 2001)

Summary and conclusions

A new approach to study the impact of ICT on student learning is emerging. This approach is based on the assumption that instead of (or in parallel to) the impact of ICT in traditional curricular knowledge, ICT might be having an effect on students' learning of skills that are important in the knowledge society. Some findings show an

effect of ICT in the development of higher-order thinking skills, independent learning and teamwork. Nevertheless, evidence is scarce and national measurement tools of these skills are just emerging. The PISA study represents an important effort in this direction.

2.3. Out-of-school use of ICT and learning results

2.3.1. Out-of-school ICT use and its educational relevance

The traditional argument that sustains the educational relevance of studying out-of-school use of ICT is based on previous evidence that social and family background has a strong influence on students' school performance. In the past three decades, a great deal of research has focused on the role of family background and school effects on educational achievement. The incentive for much of this research came from two major projects, the Coleman Report (Coleman et. al., 1966) in the United States and the Plowden Report in Great Britain (Peaker, 1971), which generally concluded that family background was more important than school factors in determining children's educational achievement. In the beginning, family background was limited to family socioeconomic status, but over time the definition has grown increasingly complex, as substantial research has found that family structure, parental involvement, educational resources in the home, and family social and cultural capital often have independent influences on children's educational outcomes, regardless of socioeconomic status. (Buchmann, 2003).

With regard to educational resources, several international studies have recognized their importance in the home as a measure of cultural capital that can facilitate educational success. Over time the types of resources included reflect technological changes in educational resources themselves. The educational resources considered are reading materials (dictionaries, books, daily newspapers), presence of computer at home, and now the PISA asks about computer-related activities such as use of educational software and access to the Internet, to appropriately reflect the rapid changes in computer usage for educational activities in recent years (Buchman C, 2002). The reason for doing this is that as educational systems fully incorporate ICT into curriculum and pedagogy, access to the Internet at home may become as important a variable as the number of books in the home (Corbett B.A. & Willms J. D., 2002: 8).

Some authors have even suggested that a new type of 'technological capital' is emerging, which is considered as both a subset of, and an addition to, traditional cultural, economic and social forms of capital in the information age (Hesketh and Selwyn, 1999; Howard, 1992). Possession of technological capital enables individuals to become producers and distributors of their own cultural products, rather than active or passive consumers of the products of others (Kenway, 1995).

In a similar vein, Emmison & Frow (1998) explore whether or not the skills and competencies that ICT use entail can be conceptualized as a form of cultural capital. Although these competencies play no part in Bourdieu's original formulation, they argue that the concept is sufficiently flexible to incorporate these additional dimensions. They state implicitly that within the overall arguments that Bourdieu

deploys in relation to the concept of cultural capital, there is an assumption that an early exposure within the family to the use of scientific instruments, machines and other forms of technology could be as efficacious in bestowing privilege and advantage on children as the more traditional forms of competence in the fine arts (Emmison & Frow, 1998: 42).

These authors argue that, as with all technologies of learning, pre-existent familiarity and competence in the use of information technologies must generate a sense of security in relation to the academic culture legitimated by the school. Therefore, an unequal distribution of skills and competences related to the use of information technology is likely to have effects similar to those of the unequal distribution of cultural capital (Emmison & Frow, 1998: 42).

Although less documented, a second important argument that backs the need to look at out-of-school uses of ICT refers to the importance of individual and peer-to-peer learning with ICT. Digital technologies offer young people unlimited access to a whole world of information and practices that are running in parallel with more controlled and traditional learning environments such as schools and homes. Therefore, the impact of these new 'informal' spaces of learning on students' cognitive skills, approaches to life, values and lifestyle becomes an important matter of research.

2.3.2. Evidence on out of school use of ICT and school subject learning

There is not much research about the direct impact of out-of-school use of ICT in curricular learning. With the precaution that, as we have explained, PISA measures not only curricular knowledge but also skills to apply knowledge, its findings are relevant for this section. A strong finding from PISA (2003) data is that the correlation between home ICT use and academic attainment is greater than between school ICT use and academic attainment in most countries, particularly in mathematics. Further study is required to fully understand what is underneath this finding, but it seems that ICT at home makes school students comparatively more experienced and confident ICT users, and these variables show a clear positive relationship with school performance. This is partly because students with low home access are more likely to come from disadvantaged backgrounds, but the observed gap cannot nearly be explained by socio-economic status. Thus, the disadvantages faced by students whose parents have low educational or occupational status are likely to be exacerbated where they also do not have access to computers (OECD, 2006:66).

The PISA evidence confirms previous studies showing particularly strong association of performance with home access and usage. For example, Ravitz, Mergendoller & Rush (2002),² conclude that lack of access to computing at home is a more substantial barrier to achievement than lack of access to computers at school. Another example is a British study that conducted research in 12 schools in England (Valentine Marsh, Pattie & BMRD, 2005), that showed that students aged 11 and 14 years using ICT at

² In a study based on student achievement data taken from the Iowa Test of Basic Skills and the Test of Academic Proficiency (ITBS/TAP), given to 31,000 students from over 300 schools, and school data from the School Technology Inventory completed by school or district-level administrators in the state of Iowa.

home for educational purposes performed statistically significantly better in mathematics. ICT was perceived to increase pupils' confidence and motivation by making schoolwork more enjoyable (OECD, 2006).

These findings are of great importance for ICT for education policy because they suggest that despite the effort in many countries of giving close to universal access to computers at school, "it is not clear that this school-based access has an effect strong enough to compensate for the effect of lacking a computer at home" (OECD, 2006:57). Furthermore, several studies are showing that to really assess learning through the use of ICT, besides access and frequency of use, it is important to look at what young people are actually doing with these technologies out of school. There seem to be differences in use depending in students' social and cultural capital. For example, Peter & Valkenburg (2006), in a study carried with Dutch adolescents aged 13-18, conclude that socio-economic and cognitive resources shape their use of the internet as an information and an entertainment medium: adolescents with greater socio-economic and cognitive resources used the internet more frequently for information and less often for entertainment than their peers with fewer socio-economic and cognitive resources (p.293). This gap in use is referred to as "second-level digital divide", where a difference remains in the capacity to use ICT (Hargittai, E. 2002). Therefore, the concept of the digital divide becomes more complex in the sense that it does not only refer to the distance between the ones that have access to ICT and those that have not, but also to the degree in which the ones that have access can take advantage and engage with ICT (Selwyn, 2004; van Dijk, 2006; Peter,J.,Valkenburg, P.M, 2006).

Summary and conclusions

There are two arguments that support the need to look at out-of-school use of ICT. The first one, based on decades of sound research, is that students' family background (i.e. family income, educational resources at home, family structure, social and cultural capital) affects their educational performance. These findings lead some educational experts and international studies to explore the role of technologies, both as a part and an addition to cultural, economic and social forms of capital. They suggest that a new type of 'technological capital' is emerging. The second argument, more recent and therefore less documented, is that a great amount of learning with ICT takes place during individual and peer-to-peer use in informal learning settings. PISA (2003) and other studies find a positive relationship between ICT use at home and student achievement, but show at the same time the need for further study.

2.4. Out-of-school use of ICT and other learning outcomes

This new area of research emerges fundamentally from the argument stated above, that young generations might be learning new skills as a consequence of out of school intensive use of ICT, where individual or peer-to-peer use are most common. Some facts that support this assumption are:

- As described earlier, PISA (2003) shows that ICT use at home is more intense than at school. Although there is a vast difference among OECD countries, a range from 25% to 70% of pupils aged 15 use computers at home on nearly a daily basis and only 1%-25% use it at school –the average values being 50% and 8%, respectively.
- PISA (2003) also reveals that only a small minority of students engages frequently in pure educational ICT use, employing educational software. More intensive use is found in Internet search-engines, playing video games, word processing and e-mailing.
- Consistent with the above, recent studies show that today's teenagers are increasingly spending more time using home digital media rather than watching TV. The figures for the US show 13-to-17-year-olds spending 3.5 and 3.1 hours every day respectively (Grunwald (2004) as cited in Pedró, 2006: 2)
- Among digital media, videogames seem to be a common activity, particularly for male students. Nevertheless, PISA (2003) finds that a similar proportion of students that play videogames frequently (around 50%) use Internet to look things up and do word processing with the same intensity.

Research findings of learning outcomes in this area of research, have similar problems to those described in section 2.2., in relation to the lack of adequate instruments to measure these skills. Behind this approach is also the notion of learning as a process of participation in practice rather than a process of acquisition of factual knowledge, where the ability to 'apply' knowledge is more important than 'knowing'. The assumption here is also that uses of ICT out-of-school are encouraging young people to learn in different ways than in the school setting.

Within this area, special attention has been placed to videogames. The reasons are mainly two:

1. Videogames have proved to be highly motivating for younger generations in and out-of-school contexts (Kulik, 1994; McFarlane, A. & Kirriemuir, 2006).
2. In the belief of some experts, videogames undertake a number of activities similar to those of the 'real world', and therefore help develop the required competencies to work and communicate effectively in the 21st century (Gee, 2003; BECTA, 2001; McFarlane, Sparrowhawk, & Heald, 2002; Sandford, et. al, 2006). Among those activities are: experiment with different strategies, perform calculations, manage multiple resources, budget, plan, and experiment like a scientist testing out emergent hypotheses in order to solve complex problems (Futurelab, 2006).

Nevertheless, this is also an open area of research and debate, where evidence regarding the effects of computer games on learning is still scarce, context-dependant and incomplete. Some examples of positive effects are:

- Cognitive abilities: using computer games favors the development of complex thinking skills related to problem solving (Keller, 1992), logical thinking (Inkpen et.al.1995; Higgins 2000; Whitebread 1997), strategic planning (Jenkins, 2002; Keller, 1992; Mandinach, 1987; McFarlane et al., 2002) and self-regulated learning (Rieber, 1996; Zimmerman, 1990).
- Learning styles: Computer games enable the development of different learning styles, since speed and difficulty level can be adjusted according to the player (Jenkins, 2002).
- Peer collaboration: An early study (Greenfield 1984), found that half of all young people who spent time in video game arcades were using the arcade more as a social gathering space than anything else. Additionally, Fromme (2003) describes several surveys indicating that playing games with *others* is popular with German children, while Tobin (1998) argued that boys' gaming was not simply a process of 'playing the game' but embedded in social interactions. (FutureLab, 2006:15)

On the other hand, videogames, as well as other technology-related activities, are, today, a matter of discussion where there are conflicting positions in some aspects and concern in others. The most important issues are the following:

- Some experts state that ICT activities are very time-consuming and neglect other activities of more value for youngsters, such as social play and physical recreation. In contrast, others claim that youngsters go only through transient phases of excessive involvement, and that these types of activities are brain stimulating.
- Some researchers indicate that these activities, particularly videogames, enhance violence by modeling influence (Anderson and Buschman, 2001). On the other side, others state that videogames help to cope with aggression (Emes, 1997).
- PISA (2003) shows that there is a gender gap, where males are more likely to play games and to do programming than females. For many this is a matter of concern considering that school curricula and assessment are expected to incorporate more advanced computer- related skills.

Summary and conclusions

As with the other areas of research reviewed in this paper, the impact of ICT out-of-school use on other learning outcomes is still a matter of debate and open research. Nevertheless, there is data that points towards intensive out-of-school use of ICT and therefore shows the relevance of looking at possible unexpected learning outcomes, particularly those that rest in control of the learner. Within this domain, particular attention has been given to the use of videogames. Although again evidence should be

taken with caution, it suggests that ICT use out of school enhances cognitive abilities, differentiated learning styles and peer collaboration. Finally, the benefits of out-of-school ICT related activities, particularly videogames, is a matter of intense debate. Among the most controversial issues are potential addictive attitudes towards these technologies, enhancement of violent behavior and gender stereotyping and cognitive gap.

3. General Conclusions and policy recommendations in the context of the NML activity

The aim of this paper was to synthesize the most important evidence and interpretations regarding the relationship between ICT and learning results. As discussed, this is a relatively new area of research, where no conclusive results have yet been found and instead much debate is going on.

3.1. Conclusions and recommendations for future research

The following is a synthesis of the most important conclusions and some recommendations about the research in this area:

1. Two central approaches can be identified in the study and assessment of the learning impacts of in-school ICT use:
 - a. A more traditional approach, which expects to find direct or indirect improvements in subject-based learning as measured in standardized tests.
 - b. A new approach linked to the emergence of ICT, which expects to find learning in terms of skills for lifelong learning that are important for the knowledge society, such as independent learning, team-work and higher-order thinking skills.

In the first approach a large amount of systematic research can be found but with no conclusive findings regarding the positive or negative impact of ICT in education. Nevertheless, most of the studies reviewed point to the conclusion that the relationship between ICT use and subject-based learning is non-linear and therefore less simple than expected. Consequently, more complex models of study should be explored. Based on research findings, these models should at least consider a set of interactions between the learner (with his social and individual characteristics), the specific school subject task, school and pedagogical conditions (called here ‘exogenous factors’), and technology-related aspects (called here ‘endogenous factors’). By shedding light on these relationships, deeper understanding may emerge regarding the specific role that ICT can play to improve students’ learning in school.

In the second approach, research is still in what could be called a ‘narrative’ or ‘argumentative’ phase, where research findings are used to support the claim that national and systematic assessments of these new skills are needed. In this context, efforts should be placed in developing the adequate evaluation tools

to measure these '21st century skills'. Additionally, it is important to find international agreement on which are these skills, as well as on the best indicators to measure their progress on young generations.

2. With regard to out-of-school use of ICT and learning impacts, research 'borrows' evidence from studies that have consistently shown an influence of students' economic, social and cultural capital on educational achievement. Research in this area intends to learn if a new form of 'technological capital' might be emerging. Although results are consistent in showing a positive relationship between ICT use at home and student learning, further study is required to fully understand what other possible relationships might be underneath these findings.

Additionally, studies regarding out of school uses of ICT suggest areas of learning where youngsters alone or in network with their peers have control over their learning, surpassing traditional structures of learning where parents or teachers normally have the control. This opens a very important area of research where new issues should be addressed such as what youngsters are learning in these informal spaces of ICT use or how these new learning outcomes might be affecting their relationship with traditional structures of learning such as home and school.

Furthermore, it seems important to study if alongside the variables associated with the 'literary culture' of youngsters, new variables associated with an arising 'digital culture' should also be considered as part of the cultural capital students bring to schools. In other words, it is important to learn more about the changes that access and use of ICT at home are producing in the skills, values and practices of younger generations and to what extent these changes might be explaining some of the differences in student's school performance and school culture integration.

Finally, to correctly assess the real social impact of ICT for education policies, evidence shows that it is critical to learn more about what is happening at home and how this is influencing students' school learning and curricular performance.

3.2. Policy implications and policy practice recommendations

Research findings presented above suggest some guidelines for future ICT and education policy and practices related to NML. Among the most important are the following:

1. Educational policies should consider the skills, values and practices developed by youngsters through the use of ICT outside the classroom. Some policy practices could be:
 - a. The creation of incentives to promote more systematic research on the types of learning related to the use of ICT out of school and further

- understanding with regard to the potential positive and/or negative effects on school curricular learning.
- b. Based on the evidence about learning with ICT, national curriculums should be revised and redefined to include valuable skills and knowledge, as well as educational methodologies and activities found in informal settings. At the same time educational experts together with educational practitioners should explore in more depth the limits or boundaries to the transformation of school cultures, curriculum and pedagogies.
 - c. The creation of institutional links and channels of communication with youth-related institutions and informal youth networks of ICT users. This would allow a better understanding of the interests, values and expectations of this new generation of learners, and establish a closer relationship between the educational system and young generations' 'outside' world.
2. Educational policies should consider parents' expectations and concerns regarding their NML sons and daughters. Some policy practices suggested are:
 - a. The creation of institutional links with NML's parents, through, for example, the formation of councils.
 - b. The development of a set of guidelines to NML's parents based on new evidence about the values and styles of life of this generation.
 3. Finally, policies should consider the technology industry. Some policy practices should be:
 - a. Take into account technology industry's know-how (i.e. what they have learned as to what works and what does not work in learning with ICT) for the development of future educational policies
 - b. Promote R&D on formal and informal learning with technology.
 - c. Promote the inclusion of educational experts in the design and development of new software and applications for educational use.

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