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1-TO-1 IN EDUCATION: Current practice, international comparative research evidence and policy implications

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Abstract

Over the last decade, more and more public and private stakeholders, in developed and developing countries, have been supporting 1:1 initiatives in education (i.e. every child receives her/his own personal computing device). These 1:1 initiatives represent a qualitative move forward from previous educational experiences with ICT, inasmuch as every child is equipped with ubiquitous access to a personal device (usually laptops, netbooks or handhelds). The paper tries to systematise the most salient evidence about 1:1 initiatives in education drawing on official websites, program evaluations and academic meta-reviews. Information is provided about the policy expectations, program designs and the challenges for an effective implementation of 1:1 initiatives in education. Given the limited body of evidence, the paper raises unsolved questions about the cost-effectiveness and educational impacts of 1:1 computing in education.

Résumé

Au cours de la dernière décennie, de plus en plus d'intervenants du public et du privé des pays développés et pays en voie de développement, soutiennent les initiatives de 1:1 dans l'éducation (chaque élève dispose d'un ordinateur pendant les cours). Ces initiatives représentent une avancée qualitative par rapport aux expériences antérieures d'enseignement avec les TIC, dans la mesure où chaque enfant est équipé d'un accès universel à un dispositif personnel (généralement PC portables ou ordinateurs de poche). Le rapport tente de systématiser les preuves les plus tangibles dans l'élaboration des initiatives 1:1d'éducation sur les sites Web officiels, des évaluations de programmes universitaires et des méta-commentaires. L'information est fournie sur les attentes des politiques, des conceptions de programmes et les défis d'une application efficace des 1:1 initiatives dans l'éducation. Compte tenu de l'ensemble limité d'éléments de preuve, le document soulève des questions non résolues sur le coût-efficacité et les impacts pédagogiques de l'approche 1:1 informatique dans l'éducation.

INTERNATIONAL CONFERENCE ON 1-TO-1 IN EDUCATION

CURRENT PRACTICES, INTERNATIONAL COMPARATIVE RESEARCH EVIDENCE AND POLICY IMPLICATIONS

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Background paper

22-24 February, 2010

Vienna, Austria

www.bildung.at/nml-conference2010

An international conference hosted by the Austrian Ministry of Education and jointly organised by the Inter-American Development Bank (IDB), the organisation for Economic Cooperation and Development (OECD), and the World Bank (WB).

1. Introduction

Low-cost computer devices, ranging from handhelds to the current reinterpretation of laptops or netbooks, have gained an important market niche. Some countries are beginning to invest more in '1:1 computing' (i.e. every child receives her/his own personal computing device). This is based on a belief that, by enabling every pupil to connect to the Internet, and to each other, in order to access valuable resources irrespective of place and time, countries can help to bridge the digital divide while at the same time transforming education to better suit the needs of networked knowledge societies.

Uruguay, for example, where every primary school student now receives a free laptop and Portugal, where the government is also rolling out a scheme for every student to have their own laptop, have made bold decisions to invest in '1:1 computing' for all of their students, and many other countries are engaged in pilot projects at a smaller scale.

While many initial investments in this area were based more on faith in a concept than on hard evidence, some interesting and useful lessons and models are emerging to help the further development of 1:1 initiatives.

The paper tries to systematise some of the most salient evidence about 1:1 initiatives in education drawing on the available information from official websites, program evaluations and academic meta-reviews. It aims to provide an adequate framework for the debate regarding the following questions:

- What are the lessons learned from current experiences?
- What are the drivers of these 1:1 initiatives?
- What are the challenges to address in future developments of 1:1 initiatives?

- How do school systems drive these policy initiatives towards substantial gains in school quality and effectiveness?

2. Opportunities and risks of 1:1 in education: international perspectives.

2.1. The policy expectations: why are countries investing in 1-to-1?

A typical 1:1 program provides: 24/7 access to an ICT device, at school connectivity and educational software. These 1:1 initiatives represent a qualitative move forward from previous experiences in relation to ICT in education. The intention is to provide every learner with ubiquitous access to ICT, 24 hours per day and 7 days per week. Students receive a personal device (netbooks, laptops, handhelds,...) permanently connected to the Internet through their schools' wireless networks, loaded with contemporary productivity software (e.g., word processing tools, spreadsheet tools, etc.) and additional educational software.

Prior attempts of 1:1 in education have involved different devices (handhelds, mobiles, computers and laptops) in developed and developing countries. Handhelds (more affordable than notebooks) opened the door to 1:1 in education. Over the last decade, more and more public and private stakeholders across the world have been supporting 1:1 initiatives in education. The State of Maine (US) was the first to equip every 7th and 8th grade student and every 7th through 12th grade teacher state-wide with personal access to learning technology. Yet, the One Laptop per Child initiative (OLPC) initiative may have inspired the development of a new category of low-cost devices, netbooks, which, together with smartphones, seem to be the technological drivers of contemporary initiatives. The OLPC initiative also contributed to setting the stage for the policy rationale of future initiatives aimed at struggling with the digital divide: namely, that children can learn by themselves if left alone with a device[1].

The decreasing cost of ICT devices, combined with the lighter weight of laptops and increasing availability of wireless connectivity, have been the main enablers of the rapid spread of such initiatives and their implementation at a broad scale. The efficient production of ICT devices has opened a new window of opportunities in education, clearly visible in developing countries. The development of new technological devices has been accompanied by pressure from vendors to incorporate them in large scale initiatives. Less expensive laptops designed for children and schools have become available, for example, the XO computer, designed and distributed by OLPC, and the Intel Classmate personal computer. Ultralow-cost computers such as these typically include flash memory instead of a spinning hard drive, smaller screens, and fewer external ports. Moreover, ultralow-cost laptops offer features of particular interest to schools in developing nations, such as low power consumption and a free or low-cost operating system (Zucker and Light, 2009). The recent development of the cloud computing concept (services and applications that reside on the web, rather than the local computer), also implies a substantial boost to this type of solution.

Public and private stakeholders have spent large sums of money on 1:1 initiatives. With the declining costs, policy-makers around the world are investing large sums of money in ICT devices for students and teachers in elementary and secondary schools. Despite the reduction of per unit costs, the amount of money being spent on this kind of initiative is non-negligible. The cost of ICT programs consists of much more than the price of buying computers, or other devices, and connecting them to networks. Schools must consider the total cost of being involved in this kind of program. The costs may include the training of teachers and administrators, technical support, software, and the replacement costs of ageing equipment. In the United States, the direct and indirect costs of 1:1 programs per client have been estimated at over USD 1000 annually (www.classroomtco.org/gartner_intro.html). In the developing world, where labour costs are lower, a large scale initiative like Plan Ceibal in Uruguay has been declared to cost annually around USD

[1] See also "A hole in the wall" in India (www.hole-in-the-wall.com).

300 per pupil. The implementation of 1:1 initiatives requires much more investment than simply the acquisition of the hardware. The hardware itself represents only about one-third of the total cost in a developing nation, whereas training, service, and technical support account for more than a half (Zucker and Light, 2009). However, and all things considered, it would be a mistake to compare investments in 1:1 computing to a baseline of zero. Nowadays, no one would suggest that all computers and Internet connections be removed from schools, and it does not seem reasonable to imagine the successful introduction of ICT in schools without minimal training of the teachers, regardless of their age. Alternatives to personal devices, such as desktop computers, represent substantial costs in many countries over the past decade. It is reasonable to expect that the introduction of 1:1 devices in schools could reduce the public and private spending on textbooks as main educational resources. In addition, ICT connectivity permits the monitoring of classrooms and a continuous assessment of learners, which could increase the overall efficiency of current evaluations of school systems.

Policy drivers of 1:1 initiatives include: providing ICT skills, reducing the digital divide and improving the quality of instruction. Existing evidence about the introduction of ICT in education has shown very clearly that the presence of computers in labs does not guarantee its use by teachers and learners (OECD, forthcoming). The emergence of 1:1 computing as a technology-rich educational reform where access to technology is not shared but where all teachers and students have ubiquitous access to ICT devices, means overcoming these limitations by incorporating ICT devices throughout the pedagogical process. The main goals of initiatives are, in summary, the following: to provide learners with the ICT skills and competencies necessary for the economy and society; to reduce the digital divide between individuals and social groups and their access to ICT, not only at school but at home; and, to improve the quality of instruction, making it more "student-oriented," in order to elevate academic achievement, bridging the gap between formal (school) and informal learning.

Main conclusions

- There are three main goals associated with 1:1 computing initiatives in education: young generations acquiring ICT based skills and competencies; the reduction of the digital divide between individuals and social groups; and improving educational practices and academic achievement.

- The reductions in the cost of learning devices and connectivity have made large scale initiatives financially more feasible.

- The rapid spread of 1:1 initiatives entailed a large investment of public and private funding in ICT in both developed and developing countries.

Raising questions

- What are the political reasons behind 1:1 initiatives?

- How many and what kind of partners are participating?

- How have budget constraints limited the implementation of 1:1 initiatives?

2.2. Supporting users: how are teachers and pupils supported?

Access, competence and motivation are the necessary conditions for teacher's use of ICT devices in class. No technological innovation has brought improvements in economic efficiency and social welfare without the adequate social practices (productivity paradox). Distributing technological learning devices in

schools does not guarantee that they will be used appropriately or even used at all. In other words, 'although access is important, it is not sufficient'. In order for teachers to use ICT devices in the classroom they must have access to ICT, know how to use ICT and also be motivated to use it. Good access to a high quality ICT infrastructure is necessary in order to increase the use of ICT devices in school. Competence to evaluate and to apply ICT at the appropriate moment in the classroom is another central factor. Finally, without knowledge about when and how to use ICT devices, the levels of motivation for actually applying such tools in the classroom are expected to be low (OECD, 2009).

Teachers need a clear vision of what the learning goals of these initiatives are. Availability of computer technology alone will have little or no impact on the intellectual challenge of teachers' lessons or the students' styles of learning. It seems very clear that simply providing schools with computers is not enough to increase student achievement or to change the nature of instruction and learning. Educational change requires a holistic approach in order for the ICT promise to become a reality in schools. Learning goals, curricula, teaching strategies, didactics and assessments must change in order for this technological opportunity to be beneficial. Some of the resistance to these kinds of programs is based on the lack of support deployed to pupils and teachers. Project leaders must provide teachers and administrators with a clear vision of how computers are to be used. As Drayton et al. (2010) have reported after studying 14 upper elementary schools, school-level leadership helps create the conditions necessary for the maturation of these experiments. Teachers and school boards need clear instructions about the options they have and teaching models suitable for implementing this strategy. Setting the implementation goals facilitates self-evaluation by teachers and schools, and it helps identify what kind of support is necessary to fully develop all the innovative potential of the reforms. This entire process should be accompanied by a system of rewards for successful implementations and outcomes (external incentives). When teachers perceive ICT initiatives to be aligned with the content schools expect them to teach and perceive the workshop to be relevant and useful to their teaching, they are more likely to integrate technology into their day by day work (Kanaya et al., 2005).

High quality infrastructure and readily available technical support also appear to be important for 1:1 initiatives to succeed. Difficulties in ensuring adequate resources for purchasing and maintaining hardware and software (including policies working with privative software) can reduce the likelihood that teachers will use technology with their students. The technical infrastructure, including the availability of hands-on support, is also a significant factor in shaping teachers' use of ICT in the classroom. For classrooms using wireless networks, the reliability of the network is frequently an issue and a barrier to widespread use by teachers (Penuel, 2006). Furthermore, even when access to computers and wireless connectivity is sufficient, perceptions among teachers that there is limited access to timely technical support from school-based or district staff can hinder their integration of technology into the curriculum. The programs in which teachers report a high degree of reliability regarding ICT devices often are programs which have both technical support staff devoted to helping with the program and ready access to outside professionals when faced with more substantial technical problems. Ensuring that all students' devices are working makes the class less disruptive and doesn't create differences between students with devices and students without devices (Zucker and McGhee, 2005). The homogeneity and quality of technical support makes it less likely that teachers will have to develop two sets of assignments. Being able to count on the reliability of the school's wireless network is also critical, as students are often using their devices to access resources available on the Net (Light et al., 2002). It is also important to consider the importance of the role of students in providing the first line of technical support in several 1:1 programs (Light et al., 2002). New millennium learners are favoured by an intense familiarity with ICT devices and connectivity outside of school, which makes them expert assistants in the classroom.

Formal and informal professional support has been identified as one of the necessary requirements for the successful implementation of ICT. Formal professional support has been a critical component of many 1:1 programs, and the adequacy of these activities has been reported to be important for the

effectiveness of the implementation process as a whole. Formal training focused on providing teachers with the skills they need to use the technology has been reported to be effective, but many teachers reported that what was most critical was that the formal training be focused on helping teachers integrate technology into their class instruction (Fairman, 2004; Harris and Smith, 2004). However, teachers not only require training in ICT and its integration in pedagogical practices, they also need other specialists to assist them in adapting the curricula and assessment to the skills of the 21st century. Content specialists can help teachers with finding educational digital resources, which have to be available and appropriate, and integrating technology into specific content areas (Silvernail and Harris, 2003). Some programs, for example, have assigned staff (either internal to the school or external) to help teachers on an as-needed basis with technology integration (Fairman, 2004; Light et al., 2002). Some of the professional support that is targeted towards helping teachers to become more "student-centered" in their teaching has been especially effective in transforming instruction in classrooms where learning technologies are found. The objective of this training is to help teachers develop extended problems and projects that use real-world resources, student collaboration, and computer tools to reach solutions or to create final products. Comparison group studies of teachers suggest that ICT devices can facilitate more use of project-based learning and cooperative grouping strategies (Lowther et al., 2001). The Inter-american Development Bank, for example, has developed a framework for supporting countries to consider all these requirements when implementing 1:1 projects. Informal professional support has been also proven to be very effective. Informal help from colleagues within the school is another form of professional support. Peer to peer learning among teachers has shown to be a very successful driver of pedagogical innovation. A number of researchers reported that they observed teachers helping each other with technology problems or engaging in joint curriculum planning, and some have even reported that teachers prefer this form of professional development above others (Peunel, 2006).

Main conclusions

- Availability of computer technology alone will have little or no impact on the intellectual challenge of teachers' lessons or students' styles of learning. It seems very clear that simply providing computers to schools is not enough to increase student achievement or to change the nature of instruction and learning.

- Professional development and technical support determine the level of ICT use by teachers and how they benefit from this educational change.

- Some of the most effective support to teachers comes from formal training by ICT specialists who are focused on their subject matter, peer to peer informal learning and trainers promoting a more "student-centered" pedagogy.

Raising questions

- What kind of support has been provided to teachers in the 1:1 initiatives?

- Which best practices in professional support are the most difficult to scale?

- What kind of technical support and infrastructure has been provided to schools?

2.3. Monitoring use and results: how do countries know what is going on in the terrain?

Monitoring and program evaluation should play a central role in 1:1 initiatives. ICT initiatives need to be monitored in order to establish priorities for funding and to give guidance to teachers and program developers in their implementation. Most innovations in educational technology combine social,

pedagogical, and technological elements, and program designers must constantly adapt and reconfigure these elements with the guidance of available evidence. New governance of education needs sound and consistent research evidence in order to generate consensus around essential reforms. The increasing popularity of 1:1 initiatives, taking into consideration the wide variety of stakeholders in education (policymakers, administrators, teachers, parents, and students), makes the need for monitoring, evaluation and the use of sound research-based evidence of effectiveness especially critical at this time. Regional, local and school actors often must choose when applying their efforts to different policy reforms. Data on effectiveness can help inform their decision-making progress.

Technical platforms to monitor use and pedagogical audits to observe the classroom are valuable. We know that the impact of any technology depends on how it is being used, in what context, and for what purposes. To examine the impact of 1:1 initiatives on teaching and learning, we need first to understand how 1:1 devices are being used and how this use plays a role in teaching and learning in a complex social context. Knowledge of these issues can not only provide a sound understanding of the learning practices in 1:1 computing classrooms but can also offer an in-depth analysis of the possible challenges and issues that may rise in learning environments with ubiquitous computing (Dunleavy, Dexter, and Heinecke, 2007). Answers to these questions can be of tremendous value to scientists, policymakers and educators.

Independent research and program evaluations should carry on quasi-experimental designs much more focused on the use of ICT and the outcomes of 1-1 initiatives. Although they are difficult to conduct, a significant number of experimental and quasi-experimental studies are needed if 1:1 programs are to provide stronger research-based evidence warranting investments in 1:1 initiatives. Although 1:1 computing initiatives began more than a decade ago, research in this field has not been able to keep up with its rapid development and expansion (Penuel, 2006; Warschauer, 2006). This was especially the case in the nineties, when a meta-review conducted by Penuel et al. (2001) found that the research was scarce, and that the available studies suffered methodological problems and lack of quality. In the first few years of the 21st century there has been a considerable increase in the number of 1:1 computing evaluation and research studies (Lei, Conway, and Zhao, 2007; Penuel, 2006). In a similar review five years later, Penuel (2006) identified 46 implementation studies and outcome studies on 1:1 programs. The emphasis of these studies was mainly on two areas: the implementation of 1:1 initiatives and the impact of these projects. What Penuel (2006) called "implementation studies" were descriptive studies of the initiatives. Findings from these implementation studies provide a general picture of the program's design and some inside information about the actors' opinions. However, there is little research that focuses on how laptops are being used for teaching and learning in environments with 1:1 computing (Bebell, 2005). When it comes to the question of what really happens when every child has a laptop and how the laptops are being used in classrooms, current studies provide only general information on what devices and software are used and in what spaces and time, but there is not much information on "how" the laptops are being used in teaching and learning practices. For example, studies generally report on how much class time is used on laptops (Rockman et al., 2004), the use of laptop in selected content areas (Russell, Bebell, and Higgins, 2004; Silvernail and Harris, 2003), the use of specific technology software or function (Bebell, 2005; Ross and Strahl, 2005; Silvernail and Lane, 2004), and the change in percentage of use of specific technologies such as the Internet (Russell et al., 2004; Silvernail and Harris, 2003). In sum, it has to be said that current research on 1:1 initiatives mainly focuses on the implementation process and whether or not it works, without sufficient data to show how students use their own devices. Further research is needed to provide a deeper understanding of learning practices in classrooms with 1:1 (Bebell, 2005; Roschelle, 2003). What is even more difficult to find are studies specifically testing the links between hypothesized outcomes for 1:1 initiatives and different implementation measures (such as teacher training). More studies are necessary to specifically examine the relationship between usage and outcome measures. Including information about core aspects of the design and implementation of particular 1:1 initiatives and its relation to achievement would make research considerably more useful for policymakers and program developers.

Main conclusions

- There is a very clear lack of consistent evidence from monitoring and evaluations of 1:1 initiatives. This is particularly the case of the initiatives in developing countries, although several decisions have been made to correct this situation.

- Most of the evaluations tend to be descriptive of the implementation process and program design without appropriate measures of how ICT devices are used in classrooms, changing practices and their relation to academic achievement.

- More knowledge of the relation between implementation characteristics and academic gains is necessary. Policymakers and program managers need to identify best practices of 1:1 initiatives in order to make informed policy decisions.

Raising questions

- What are the methodological approaches of current evaluations of 1:1 initiatives?

- What is the role of program monitoring and evaluation in the implementation process?

- How have the results of monitoring and evaluations shaped the design of the programs?

3. What do we know about the impact of the use of technology in education?

3.1. The transformation of teaching and learning: are there new learning models or environments emerging?

More knowledge on the impacts of the initiatives on educational practices is necessary. A number of authors suggest the importance of examining the impacts of 1:1 computing in the context of practice. Although some studies go beyond such simple examinations of technology use, effective use of technology is a prerequisite to any realization of positive educational outcomes resulting from 1:1 computing resources. Teachers' attitudes and beliefs about technology's role in the curriculum can influence how and when teachers integrate computers into their instruction (as has been mentioned above; access, competence and motivation are the main conditions for an effective use of ICT devices by teachers). The social objective associated to any educational technology (pencil, text book, and laptop) is not the success of the said technology but the improvement of the process and environment in which teaching and learning occur. Available evaluations of 1:1 initiatives should produce consistent evidence about how ICT devices are being used for teaching and learning. As many schools are currently aspiring to 1:1 computing, it is necessary for these teachers and school boards to know how these devices can be used to support a wide range of educational innovations.

A teacher's perception of ICT in relation to students is determinant for changing practices. When teachers do not perceive that expected uses of technology are closely aligned with the curriculum, they use it less often. It is necessary to underline that teachers have a crucial role in ICT's impact on learning because they facilitate or restrict the learners' opportunity to creatively use their ICT devices. Case studies of teachers in 1:1 programs have shown that teachers' beliefs about students, the potential role of technology in learning, and the availability of high-quality digital content influence the degree to which they use ICT devices with students (Trimmel and Bachmann, 2004; Windschitl and Sahl, 2002). Teachers who are confident that students are capable of completing complex assignments on their own or in collaboration with peers may be more likely to assign extended projects that require ICT devices use and allow students to choose the topics for their own research projects. Teachers who view technology as a tool

with a wide variety of potential applications are more likely to regularly use ICT devices with students. In addition, those teachers who believe that there are adequate software and Internet-based resources available to help teach their particular content area may use ICT devices with students more often than teachers who believe that there are simply not enough high-quality materials available (Trimmel and Bachmann, 2004).

Program designs could facilitate the emergence of more favourable perceptions among teachers. Particular program design features may influence teachers' beliefs in making them likely to use learning technologies in conjunction with student-centered modes of instruction. The most common uses appear to reflect the fact that the teachers are in an "adaptation" stage of technology adoption. In other words, they are adapting traditional teaching strategies to incorporate more adult productivity tools and are having students work independently and in small groups, but they have not yet begun to widely implement more student-centered strategies for instruction, such as project-based learning. The design of 1:1 initiatives needs to include support for teachers in their process of adaptation to the potential of ICT devices.

Available evidence identifies different determinants of teacher's incorporation of ICT in their lessons. Research has been carried out on the determinants of teachers' incorporation of 1-to-1 opportunities for pedagogical innovation. There appears to be substantial variation in technology use occurring across the 1:1 initiatives. In what is considered one of the most consistent evaluations of a 1:1 initiative, Shapley et al. (2010) developed a technology immersion index to quantify the level of implementation across 22 1:1 middle schools. After four years of implementing the Texas Immersion program, the authors reported that: "results for the Implementation Index combined with evidence from standards-based scores suggest that about a quarter of middle schools, with Implementation Index scores ranging from 0.39 to 2.58 standard deviations above the mean, had a stronger presence of the components of Technology Immersion compared to other schools, and thus a higher level of implementation that more nearly approximated expected standards" (Shapley, et al, p. 33, 2010). Shapley et al. provides a very detailed quantitative summary of the role that various factors play in schools' implementation of 1:1 programs, including school level administration. Looking across the 21 participating 1:1 middle schools, the study authors wrote: "Core-subject teachers' extent of Classroom Immersion was associated at a statistically significant level with their perceptions of the strength of the school's administrative leadership (r = .59), teachers' collective support for technology innovation (r = .67)" (Shapley et al., p. 33, 2010). . Shapley et al. found that teachers' level of implementation was statistically significantly related to the "quality of professional development (r = .47)" (Shapley et al., p. 33, 2010). These results underline that 1:1 programs depend largely on teachers for success. It is not surprising that preparing teachers through professional development is important for a successful implementation.

Main conclusions

- The presence of ICT devices in schools does not necessarily change the strategies of the teaching and learning of teachers and pupils.
- The use of ICT devices in 1:1 initiatives varies largely across schools.
- Teachers need clear models of reference and specific support in order to incorporate ICT devices in innovative pedagogical practices.
- A holistic perspective is necessary for 1:1 initiatives to be a driver of the educational change in schools.

Raising questions

- Changing the teaching and learning practices: is this a specific goal of 1:1 initiatives?

- What actions have been implemented in order to promote such a change?
- What is the available evidence of success or failure in the promotion of this change?

3.2 Impact on student outcomes: does 1:1 improve student results?

Despite the limitations of available evidence, independent research has pointed out the positive impacts of 1:1 initiatives in writing and ICT skills. A review of 30 studies of 1:1 programs found only a few with rigorous designs, but the studies measuring learning outcomes showed consistent, positive effects on students' writing skills (Peunell, 2006). However, studies finding evidence of other improvements in academic achievement in 1:1 programs involving large numbers of schools, particularly studies using quantitative methods, are scarce. Experimental designs with random assignment or quasi-experimental designs with pre- and post-test data (as the IDB is carrying on in Peru) on both treatment and control groups are difficult to find. Schaumburg (2001), for example, conducted a quasi-experimental study that examines the effects of providing students with laptops on their technological literacy. She studied the effects of a program that provided laptops to students in a high school in Germany. She found that the students with laptops made greater improvements than did the comparison group of students responding to a researcher-developed test of their knowledge of hardware and the laptop's operating system, common productivity tools, skill in using the Internet, and knowledge of basic computer security. Other comparison group studies with post-test only designs reported greater levels of technological literacy among students in laptop programs, using judgments made by researchers on the basis of structured observations of their skill in using computers and the Internet (Lowther et al., 2001). However, none of these studies used a pre-test to determine whether students had actually improved their achievement.

No consistent evidence has been provided supporting the positive impact of 1:1 initiatives on other skills. When considering not only ICT skills, studies generally report a positive impact of 1:1 computing on student outcomes in general, or on one or two specific areas. For example, using a quasi-experimental design, Gulek and Demirtas (2005) explored the impact of 1:1 laptop use on students' overall grade point averages (GPA), state test results, and district test results. They found that students who participated in the laptop program made significant improvements in their writing, English-language arts, mathematics, and overall GPAs. Russell and colleagues (2004) compared teaching and learning in classrooms with mobile cards and permanent 1:1 laptops. They reported that in 1:1 classrooms, technology was used more frequently, student motivation and engagement was higher, and students were more likely to use computers as a primary writing tool (Lei and Zhao, 2008). Specifically, 7th grade students in their second year of the 1:1 program statistically show significant improvements on ELA state assessment scores compared to non-1:1 students after assessing their prior ELA achievement. Similarly, Shapley et al. (2010) found that the "implementation strength of Student Access and Use (of technology) was a consistently positive predictor of students' *TAKS* reading and mathematics scores" and that students' use of their laptop for learning at home was the "strongest implementation predictor of students' *TAKS* reading and mathematics scores" (Shapley et al., p. 48, 2010). When Suhr et al. (2010) compared ELA test scores for a group of students who entered a 1:1 laptop program in the fourth-grade to a similar group of students in a traditional program in the same school district, they found that after two years, students in the 1:1 program outperformed the comparison group. Specifically, the 1:1 students had higher gains on the ELA test and on the subtests related to writing strategies and literary response and analysis than the non-1:1 students. Their findings suggest that "laptops may have a small effect on increasing such scores, with particular benefits in the areas of literary response and analysis and writing strategies" (Suhr et al., p. 38, 2010).

Main conclusions

- Large scale quasi-experimental evaluations of 1:1 initiatives are scarce. Pre and post-test achievement records are necessary in order to estimate the value added by ICT to the learners' progress.

- Despite the limited available evidence, evaluations show a positive impact of 1:1computing on ICT skills and writing.

- A more modest association has been found between the introduction of 1:1 and academic improvement in other domains such as mathematics.

Raising questions

- What evidence emerges about outcomes of the introduction of 1:1 initiatives in schools?

- What kind of measurement of achievement and progress has been collected from current ongoing projects?

- Is there any available evidence of the positive impacts of 1:1 computing on core skills over time?

3.3 Impact on equity: does 1-to-1 help bridge the digital divide in education?

The main 1:1 initiatives expect to reduce inequalities in access to ICT, at home and school, across social groups. There is worldwide concern that a large number of students may be excluded from ICT possibilities. In the knowledge based economy today, the demand for new skills, especially ICT skills, can generate new social divisions between those able and those unable to perform within this new context. Education should be a decisive policy instrument to reduce the digital divide where access to ICT is concerned. In fact, 1:1 initiatives harmonise the access to these devices, at home and at school, amongst young learners of all social groups. Consequently the ICT device can be also used in the home by other family members and relatives, so there may be a community spin-off effect. The expansion of 1:1 initiatives across the developing countries will help reduce the gap in access to ICT between the young generations of rich and poor countries.

Inequality in use of ICT between individuals and social groups could create a "second digital divide." Equity in education cannot be reduced to equality of access to certain resources (for example, learning technologies). Educational equity means also that the same opportunities must be made available for people to be able to benefit from these resources. Despite prior optimism, new available evidence alerts to the emergence of a second digital divide between users of ICT devices in education. . While learners with high cultural capital seem to take advantage of the learning opportunities associated with ICT skills, other learners do not (OECD,forthcoming).. New research evidence is necessary in order to identify what kind of background skills and competencies are necessary for students to be able to benefit from ICT access in education.

Focusing deployments in disadvantage situations should be one of the basic requirements of social justice for initiatives such as 1:1 computing. Giving equal access to ICT devices to learners and schools is necessary, but it is not enough. It seems reasonable to expect improvements in equality when 1:1 initiatives include this in their design as main goal. For example, Harris and Smith (2004) studied the use of laptops by seventh grade students with disabilities in the Maine Learning Technology Initiative project. They found that the laptops helped students with disabilities to improve their engagement in learning, increase their motivation and ability to work independently, and improve their class participation and interaction

with others. Similarly, Lei and Zhao (2008) reported that T. Conway identified a positive impact of the one-to-one laptop program on students with dyslexia and other reading or writing difficulties.

Main conclusions

- Large scale 1:1 initiatives are often intended to reduce the digital divide in the access to ICT at home and in school.
- The extension all over the globe of 1:1 initiatives would help to reduce the digital divide between the young generations of developed and developing countries.
- A second digital divide emerges in the school when all the learners have access to ICT devices. More evidence is necessary about how ICT are used at class and its impact over achievement.

Raising questions

- What are the equity concerns incorporated in the design of 1:1 initiatives?
- How will the poorest and the least able benefit from these reforms?
- What do we know about equity-friendly teaching strategies with ICT?

4. Lessons learnt and policy implications

Some basic lessons should be underlined from previous findings. These are:

- There are three main goals associated with 1:1 computing initiatives in education: that young generations acquire ICT based skills and competencies; that there be a reduction of the digital divide between individuals and social groups; and, that there be an improvement in educational practices and academic achievement.
- The rapid spread of 1:1 initiatives entailed a large investment of public and private funding in ICT. Despite the large amount of money invested, little evidence is available about the cost-effectiveness of these initiatives.
- The presence of ICT devices in schools does not necessarily change the strategies of the teaching and learning of teachers and pupils. The use of ICT devices in 1:1 initiatives varies largely across schools.
- Available evaluations point out a positive impact of 1:1 computing on ICT skills and writing, but more modest evidence has been found about a positive impact on other academic domains such as mathematics.
- Large-scale 1:1 initiatives could strongly limit the first digital divide in the access to ICT at home and in school. The globalisation of 1:1 initiatives should reduce the digital divide between de young generations of developed and developing countries.
- It is necessary to take into account that a second digital divide emerges in school when all the learners have access to ICT devices. More evidence is necessary about how ICT are used in class and its impact on achievement.

Finally, some weaknesses and potentialities of 1:1 initiatives have been identified and are presented as policy suggestions. These are:

- Every evaluation of a program must be defined from the beginning of the process and must be coherent with the goals and design of the initiative. Every pilot experience needs an in-depth evaluation in order to acquire scalable evidence and lessons.

- Rigorous quasi-experimental evaluations of students' achievement are necessary in order to identify what the best practices in terms of program design and implementation are. This is especially the case of the initiatives in developing countries where international organizations should be funding and promoting evaluations of 1:1 initiatives.

- More knowledge research is necessary regarding the relation between the implementation of ICT and academic gains. Policymakers and program managers need to identify best practices of 1:1 initiatives in order to make informed policy decisions. In order to improve this situation monitoring and evaluation practices need to play an important role.

- Teachers need clear goals and specific support in order to incorporate learning technologies in innovative pedagogical practices. A holistic perspective is necessary for 1:1 initiatives to be drivers of educational change in schools.

- The globalisation of 1:1 computing could help reduce the digital divide among young generations of developed and developing countries. In this sense, 1:1 computing can be seen as a friendly policy for both efficiency and equality in education.

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