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Exploring the Impact of ICTs in Education: Controversies and Challenges

Valeria Pandolfini[*]

Abstract: Educational innovation is considered as a top priority all over the world, and the potential of Information and Communication Technology (ICT) to foster it increasingly is recognized (European Commission, 2015; Eurydice, 2011; OECD, 2010). In formal education settings, however, ICT adoption often is regarded as a highly demanding challenge that usually meets resistance by schools. Although it is largely believed that decades of large investments in ICTs and the increasing digitalization of teaching and learning processes can benefit the education system at different levels, data to support the perceived benefits are limited and evidence of effective impact is elusive or even debatable (Bocconi et al., 2013; UNESCO, 2009). This essay offers a conceptual framework providing multiple angles for the assessment of ICT impact on education. It presents the various aspects to take into account and questions what is to be assessed, the appropriate methodologies to be implemented, and the most suitable indicators. Such issues are discussed in light of an Italian case study showing the complexity of ICT innovations in schooling and dealing with methodological aspects connected to the definition of a set of indicators addressed to explore technology-based school innovations.

Keywords: ICT impacts, assessment, indicators, objective-subjective evaluation

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Innovating school education: An European goal for the future

Educational innovation is considered as a top priority all over the world, and the potential for Information and Communication Technology (ICT) to foster it increasingly is recognized (European Commission, 2015; Eurydice, 2011; OECD, 2010). The Europe 2020 strategy acknowledges that an essential change of education and training is needed to address the skills and competences that will be required if Europe is to remain competitive, overcome the current economic crisis and grasp new opportunities.

The *New priorities for European cooperation in education and training* report (European Commission, 2015), drafted within the Education and Training 2020 strategic framework, identifies six new priorities that include improving people's skills and employment prospects and creating open, innovative and digital learning environments, at the same time cultivating fundamental values of equality, non-discrimination and active citizenship. So, innovating in education and training is a key priority of European Union member states and is linked directly to the Europe 2020 educational headline targets regarding early school leaving and tertiary attainment levels (Kampylis, Bocconi, & Punie, 2012).

In such a scenario, it is important first to specify what educational innovation means. The OECD/Centre for Educational Research and Innovation (OECD/CERI) defines educational innovation as 'any dynamic change intended to add value to the educational processes and resulting in measurable outcomes, be that in terms of stakeholder satisfaction or educational performance' (Pedrò, 2010, p. 12). This widely diffused definition means that educational innovation cannot be simply something new but it must be a change that creates a positive value. To better understand the process of innovation in order to contribute to an incremental improvement of the education system, the OECD (2010) proposed a systematic approach to technology-based school innovations, leading to the identification of four axes for the analysis of technology-based innovations in education:

- *policy* axis: links innovation to policy-making and policy choices that need to be made to facilitate innovation, its impact and its knowledge base. Curriculum, professional development for teachers and school leaders, and assessment are key elements;

- *pedagogy* axis: it is largely about how technology can contribute to improved teaching strategies and learning outcomes;
- *technology* axis: reflects the strong importance placing on infrastructure (access to laptops, broadband internet connection, learning management systems, etc.) as an enabler for access and equity with regard to technology in education;
- *knowledge* axis: it is linked to the role knowledge plays in innovation processes, focusing on three knowledge challenge: i) to secure that a sufficient knowledge base is established; ii) to secure effective dissemination of knowledge; and iii) to use the knowledge base.

This approach stresses the importance of efforts in monitoring and evaluation, underlying the benefits derived from empirical assessment: informing decisions about the scaling-up or the diffusion of innovations; instilling in the main involved actors the culture of output-oriented innovation (i.e. aimed at measurable improvements which can help when coping with innovation fatigue or resistance); getting value for money; and obtaining feedback on the results of particular policy measures intended to foster innovation. Nowadays most of the educational systems generally fail to adapt itself quickly to any form of educational innovation and experimentation. In formal education settings the emphasis on ICT adoption often is regarded as a highly demanding challenge that usually meets resistance by schools' actors. But, of course, there are numerous examples of implementation of schooling innovation as well as inspiring and enthusiastic teachers who have great practices to share within the European educational community which could motivate and engage other teachers across Europe (European Commission, 2013). The truth, however, seems to be that in most countries and education systems around the world, real change in education still is happening in only a very few cases, driven by heroic individuals who innovate their teaching practices and schools in relative isolation (Langworthy, Shear & Means, 2010, p. 105).

Thus, one of the most important issues refers how to assess the impact of ICTs in education and how to make many schools aware of the benefits deriving from monitoring and evaluation processes. First of all, it seems to be crucial to specify what I mean by *ICT impact*. In a wider sense, the impact can be described as the overall achievement of an intervention, and it is the ending point of an intervention involving input, process, output and outcome. In a more specific ICT-related meaning, impact could be defined

as 'a significant influence or effect of ICT on the measured or perceived quality of (parts of) education' (OECD, 2010, p. 201).

Based on such assumptions, the aim of this article is to present the multiple aspects to take into account when assessing the impact of ICTs in education, drawing different levels of analysis to get a wider understanding of the role ICTs could play in the education system. This leads to focus on indicators on ICTs in education, questioning what is to be assessed, which are the appropriate methodologies and instruments to be implemented, and which are the most suitable quantitative and qualitative indicators.

In the majority of studies the understanding of impact often is drawn toward simple outcomes on the individual level (teachers and/or students). Here I will rely on a multilevel approach that might help to avoid reducing ICT in education to a question of whether students learn better now than before because I agree with Erstad (2009) in thinking that change and outcome is about the educational system in its whole and a more realistic understanding of how impact is interrelated on different levels is needed. Moreover, this essay is based on the awareness that isolating the variable which actually causes the impact is very problematic in education, considering the complex and multidimensional of education. Thus it is very important to look at how ICTs improve teaching and learning processes within the school, assuming that not all impacts are positive or intended, but there also could be unexpected ones, the analysis of which could reveal also negative latent aspects. This issue will be discussed in light of a case study related to the Italian Plan for Digital School. The empirical discussion will allow to focus on the complexity of technology-based school innovations development. Indeed, technology includes not only devices, but also practices and knowledge related to them and the social arrangements that constitute their uses in different times, places and groups.

Indicators on ICTs impact in education: A complex scenario

As a consequence of the increased focus on evidence-based policymaking (Hattie, 2013), the national authorities of the majority of OECD countries need to move away from anecdotal and unsystematic evidence how ICTs are being used in education and how they impact on teaching and learning: The request of more precise data that could be generalized to a more extended realities is expanding all across the world.

Such a change of focus highlights the requirements of methodology and validity and leads to a focus on indicators[1] on ICTs in education: speaking about it draws a complex scenario due to different factors.

First of all, it is largely believed that the use of ICTs in education can benefit the education system at different levels: increasing access to learning opportunities, enhancing the quality of education with advanced teaching methods, improving learning outcomes and enabling reform or better management of education systems. But despite decades of large investments in ICTs and their increased use in all OECD countries, data to support the perceived benefits from ICT are limited and evidence of effective impact is elusive or even debatable (Bocconi, Balanskat, Kampylis & Punie,2013; Eurydice, 2011).

Balanskat, Blamire & Kefala (2006), reviewing several studies on the impact of ICTs on schools in Europe, concluded that the evidence is scarce and comparability is limited since each study used a different methodology and approach so that comparison among countries must be done cautiously. Trucano (2005) also reviewed a series of studies on the impact of ICTs in schools, concluding that the impact is unclear and calling for more 'widely accepted methodologies and indicators to assess the impact on education' (Trucano, 2005, p. 1). Thus there is lack of standardized definitions, classifications, data collection methodologies, operational handbooks and guidelines to better measure the real benefits of ICTs in education. To date, however, there are no data at the international level on the presence and use of ICTs in education (Gallego, Arrufat, & Masini, 2012). The lack of clarity about different impact areas of the use of ICTs in education, as well as of useful indicators and methodologies to measure such impact, hampers

[1] Indicators, as defined by UNESCO (2003), are measuring devices to assess or evaluate materials, methods, interventions, programs or projects on the basis of adopted assumptions on what is relevant. The word *indicator,* however, does not have an unequivocal definition. Literally, it means 'an indication of something that is not directly observable'. Quoting Palumbo (2010, p. 18), an indicator is 'something observable/detectable/measurable "standing for", that is used in place of, "something else" more hardly observable/detectable/measurable in a direct way'. According to Zajczyk (1997), indicators should be *valid*, capable of effectively representing the phenomenon or concept which they refer; *reliable*, seizing probably the different states of the properties of the concept; *sizable*, able to distinguish the different forms taken by the phenomenon; *adequate*, meeting the information needs behind the pursued goal; *comparable*, enabling comparisons in space and time; and *timely*, adequately available on time for decision making.

policy guidance and is an obstacle for the development of successful projects.

Moreover, countries are at different stages of introducing technology (in various forms) in schools so countries that are still at basic stage have different information needs than countries that have longer experience with the technology. To collect data across various countries at different stages of development and implementation, indicators must be sensitive to such gap among countries. Each country, based on its situation, could identify different goals to be reached. This recalls one of the most serious problem in defining indicators, that is, their 'comprehensiveness' (Zajczyk, 1997), which is the extent to which they adequately cover the domain implied by the goal statements. If, i.e., goal statements are very concrete, it might be relatively easy to measure, such as 'the percentage of schools that have a connection to the Internet'. However, when goal statements are fairly global, as is often the case in international consensus-building processes (e.g. 'provide all students with access to the Internet'), different indicator's definitions must be needed (e.g., number of Internet-connected computers per 100 students, connection speed).

Another important factor linked to the complexity of defining a set of indicators on ICTs impact in education is the difficulty to identify the direct impact of ICTs. For example, to effectively measure the differential return on investment in ICT on student learning outcomes, a policy analyst must deal with a causal relationship that isolates a single variable, such as 'computer use', from a myriad of other factors that might affect student performance, such as context and individual variables. The fundamental problem is that the collected data do not allow for cause-effect analyses; at best, they can result in strengthening or weakening particular beliefs about cause and effect. In other words, there is a strong risk of running into a 'spurious relationship'. Because correlation can arise from the presence of a lurking variable rather than from direct causation, it often is said that 'correlation does not imply causation'. In ICTs-learning outcomes causal link, it is appropriate to speak of 'concurrent causes', which affect only partially the effects expected to be obtained as a result; this means getting away from a deterministic conception, according to which only one factor, by itself considered, can produce a specific change of an expected result (the increase in student achievement).

Finally, owing to rapid changes in technology, many of the ICTs indicators used only 6 years ago are no longer relevant for shaping and

implementing policy in education. Digital technologies tend to age and even become unusable within a few years; they change very fast and even if older technology still is usable, it can be incompatible with new digital products and services or be unsuitable for their full exploitation. Thus, emerging technologies that will impact education in the future (e.g., cloud computing, mobiles, educational games, augmented reality, flexible thin displays) will require new conceptions of educational standards and assessment (Johnson et al., 2014).

A conceptual framework and indicators proposal: Toward a multidimensional approach

Given such complexity, scholars involved in the definition of a set of indicators on ICTs in education agree to adopt a multidimensional approach. Combining different sources, I draw a conceptual framework to look into the various dimensions of ICT use and to discuss possibilities to assess its impact in schooling (Gentile & Pisanu, 2012; OECD, 2010; UNESCO, 2003, 2009; Scheuermann & Pedrò, 2009). Such a framework could help look at the relevant domains and different levels at which ICTs operate in educational processes from an holistic perspective (Kikis, Scheuermann & Villalba, 2009). Indicators can be described on macro (national and local), meso (institutional and learning environment) and micro levels (teacher and student practices and outcomes, collective and individual, Erstad, 2009). Let's see more in detail each of them.

The macro level

ICTs' impact on the national level deals with:

a) curriculum development (i.e., the level of ICT integration in the curriculum, including courses on how to use ICTs effectively). It differs in different countries by method and extent (European Commission/Education, Audiovisual and Culture Executive Agency/Eurydice, 2015). In Italy, where ICTs once were mentioned as tools that might be integrated into the classroom, the new curriculum confers them more importance at all levels of compulsory education, stating they are a great opportunity for school and setting digital competence as crucial to be reached by students at the end (Annali della Pubblica Istruzione, 2012).

b) Infrastructure/widespread access. For many years, national documents and action plans show that policymakers have supported the adoption and diffusion of technologies in schools through budget allocations (i.e., significant investments in ICTs). Infrastructures could include the physical infrastructure necessary for the use of and access to ICT (e.g., laboratories, libraries and furniture), equipment such as computers, printers, projectors, technological tools and the conditions included in their purchase and use (e.g., guarantees and service support), connectivity such as access to the Internet and networks allowing their use for education (e.g., bandwidth access, and connection stability and technologies facilitating better online traffic and providing privacy protection filters for content).

Some countries have adopted instruments to monitor progresses in this area; one of the main used indicators refers to the ratio of computers and Internet access per students and per teachers. In Italy, the Ministry of Education periodically performs the 'Teaching Multimedia Equipment Survey' through a questionnaire addressed to all public educational institutions of the country[2]. This effort is aimed at revealing the instruments adopted by schools for services dematerialization, use of the Internet for teaching, number and quality of multimedia equipment for teaching in laboratories and libraries, amount and speed of Internet connections, different sources of finance to equipments, ratio of classrooms equipped with wireless connectivity, total number of computers (desktop and laptop), mobile devices, interactive projectors and interactive whiteboards. All data are updated and online published in the Scuola in Chiaro platform (http://cercalatuascuola.istruzione.it/cercalatuascuola/).

c) Digital learning resources is an important indicator of progress at a national level, is needed for exploring how teachers and students use ICTs in both receiving and producing activities. National initiatives to stimulate the production of digital learning resources have been important, yet problematic, in many countries. In Italy the Law 6th August 2008 n. 133, section 15, declares: 'starting from the 2011–2012 school year, the teaching staff shall be used exclusively online book versions downloadable from Internet or mixed book' and the Decree Law n. 41, 8th April 2009 specifies three different possible books typologies: print, online and mixed. The second typology refers to digital books (typically in PDF or ePub format)

[2] The latest survey, referring to 2014–2015 school year, involved also private schools.

equivalent to classical printed books in structure and in mode of use; the latter integrates printed or digital books with a set of varying supplementary digital materials. Currently in Italy the offer of digital publishing of school books is like a narrow interpretation of the Italian legislation, thus it foresees the design of new paradigms that efficaciously merge the authoritativeness and cultural value of school books with the advanced features and new uses of digital media (Vincelli, 2011).

The macro level includes also the local level, where it is important to consider strategies in the distribution of infrastructures/access. Referring to strategies, the focus is on the extent to which local authorities develop strategies, expressed in different kinds of documents at the national level, to give a direction for the implementation and use of ICTs in schooling. In relation to the second aspect, although there are national policies concerning the implementation of infrastructure, it varies to what extent this is followed on a local level. In Italy, the well-known divide between North and South regions with a more advantaged situation in the Northern ones (Istat, 2015) shows a digital gap with regard to both ICT initiatives and infrastructures in schools. Over the last years, Southern regions included in the National Operational Program (PON, Campania, Sicily, Calabria and Apulia) received specific resources to equip their schools with technological tools and to experience learning environments, reducing the gap with Northern regions.

Finally, at the macro level, we have to remind the importance of the overall societal attitude toward ICT use not only in the educational system, but in all aspects of life. In fact, ICT readiness and acceptance in the overall society influences the pressure and demand for ICTs in the educational system as well as the attitudes of both teachers and students toward ICT use. Possible measures of this dimension could be the dissemination of ICTs in firms, as well as in households and by individuals, as periodically monitored by several organizations internationally (Eurostat, 2015; ITU, 2014) and nationally (Istat, 2014).

The meso level

The meso level includes the institutional and learning environments. Some key institutional indicators are:

a) Leadership, which concerns how the management of school makes explicit the strategies for school development through the use of ICTs. Nowadays, probably due to the diffusion of research results regarding

mechanisms that play a role in successful educational changes (Bocconi et al., 2013), awareness is increasing that school leaders might be important as gatekeepers and facilitators in the implementation of ICTs. Another indicator concerning leadership could be how schools use ICTs as tools to make administrative and management work more efficient and effective.

b) School culture relates to the daily life of each school, including beliefs, perceptions, relationships, attitudes, explicit and tacit rules that shape and influence every aspect of how a school functions, as well as leadership, the teacher community, the school local community, the student population and so forth. Thus, it also influences the way ICTs are implemented and used in the school.

c) Collaboration, related to how schools use ICTs as tools for collaboration, could be seen as strictly connected to school culture. Collaboration could be among teachers inside the same school, among students nationally and internationally, among different schools, or among school leaders in a community. In Italy in the past years school network experiences are growing and the building of these networks is facilitated by the opportunities provided by ICTs (Fondazione per la Scuola della Compagnia di San Paolo, 2012).

Another important indicator is teacher education, with reference to teachers' ICT competence and teaching methods. It includes initial and in-service training activities related to the adoption, adaptation and updating of curriculum, methods of using ICTs and digital resources, and practices for ICT integration into the ordinary teaching practices. This could be seen as ICT literacy indicators for teacher education.

Some key learning environment indicators are:

a) ICTs use, or the ways ICTs actually are used (e.g., timing, intensity, educational methods, purposes).

b) Flexibility, or to what extent technology, at the school level, pushes for changing of the 'traditional' classroom into a more flexible teaching-learning spaces.

c) Online/offline, or the online/offline interaction combination, serves as an indication of the level of the school opening up to the outside world.

d) Digital learning resources (DLR), or the extent to which DLRs are used within the learning environment.

e) Assessment, or the extent to which assessment methods are changed and ICTs are used as summative and/or formative assessment tools.

The micro level

The micro level focuses on teacher and student practices and outcomes, both on a collective and an individual level. In relation to collective outcomes, two important dimensions have to be taken into account. The first refers to an indication of how ICT use might stimulate collaborative work among students and teachers. The second concerns sharing content, referring to what extent students and teachers upload to the Internet and share content produced in schools or the extent to which they reuse content that they find on the Internet as part of their own learning activities.

In relation to the individual level, we have to take into account (a) different learning outcomes of ICT use, both in a summative and a formative way related to learning, b) the ways in which ICTs stimulate knowledge building and problem solving among students, and c) differences in ICT competences among students, or the digital divide. Focusing on such a level, specifically referring to the students, socioeconomic factors play a key role. The literature points to students' socioeconomic background, age and gender as being key factors that might influence students' learning expectations, the degree and scope of the actual use of ICTs, and students' educational attainment (Bocconi et al., 2013).

Some of the described levels and related indicators are preconditions to use ICTs, some toward the framing of such use and some toward the actual use and outcomes. Thus, indicators on national and local levels primarily are preconditions in the way they create the platform and the basics for use by providing the technology. The framing relates to the institutional level, teacher education and the learning environment which create conditions for how ICTs could be used in educational settings, while the collective and individual aspects relate more directly to the use of ICTs themselves and to the outcomes of such use. As noted, these three levels determine the type of indicators that might be used within each of the domains. Integrating different literature sources we can further distinguish input, processes and outcome/impact indicators (Gentile & Pisanu, 2012; OECD, 2010; UNESCO, 2003, 2009; Scheuermann & Pedrò, 2009).

Input, processes and outcome/impact indicators

Input indicators are the most widely used type of indicator and are related mainly to the macro level. The greatest emphasis has been placed on input indicators regarding national policies and regulatory frameworks,

expenditure, teacher training, inclusion of ICTs in school curricula, ICT infrastructure in schools and the access of ICT equipment by teachers and pupils at home (Kikis et al., 2009).

Processes indicators mainly refer to how teachers and pupils actually use ICTs, so that they are defined also as 'utilization indicators' and could be connected to the meso level. Generally they focus on how often teachers and students use ICTs for teaching and learning, what they use and for what purposes (e.g., what kind of software they use to teach a given subject), and how they use it (e.g., whole-classroom teaching, group/individual work).

Outcome indicators often focus on the attitudes of teachers and students toward ICTs and their confidence and skills. Here, the focus could be on the development of ICT competence; its definition could be restricted to the effective use of the ICT infrastructure (i.e., use of a computer or the Internet) or it could have a broader scope (e.g., students would be able to use, search, understand and even produce different content in a digital support). The concept of digital competence (Gui, 2010) arises here, being conceived as 'the set of knowledge, skills, attitudes, abilities, strategies, and awareness that are required when using ICT and digital media to perform tasks; solve problems; communicate; manage information; collaborate; create and share content; build knowledge effectively, efficiently, appropriately, critically, creatively, autonomously, flexibly, ethically, reflectively for work, leisure, participation, learning, and socializing' (Ferrari, 2012, p. 30). More recently, attention has started to focus on the impact of ICT use on school learning (learning impact indicators) to measure the impact on students' academic attainment (Falck, Mang & Woessmann, 2015; OECD, 2011)[3].

[3] Indeed, since the introduction of ICTs in education, one of the most discussed policy questions has been its impact on educational outcomes. This explains why almost all existing data on ICTs use in education are derived from sample-based international comparative assessments that rely on students, teachers and schools for descriptions and analysis of educational inputs, processes and outcomes. International comparative educational assessments that have attempted to monitor developments in this area of ICTs fall into two categories: (a) assessments specifically dedicated to ICTs (that is, in which ICTs related indicators were the primary indicators) such as the Second Information Technology in Education Study (SITES) and (bi) assessments in which ICTs indicators were secondary (i.e., don't specifically aim to assess the spread of ICTs or their use in teaching and learning practices but provide some important data related to ICTs in schools) such as the Programme for International Student Assessment (PISA), the Progress in International Reading Literacy Study (PIRLS) and the Trends

The proposed conceptual framework leads us to consider both quantitative and qualitative indicators, whose combination is needed to get a richer understanding of the dynamics at play, taking into account input, process and outcome/impact. Quantitative indicators might be number of computers per school in each country or the median number of computers, ratios of computers to student, computers to classroom, computers to teacher and so on. Qualitative indicators are people's judgments or perceptions (e.g., change in teaching and learning methods, teacher confidence in the use of ICT, how much learners think they have improved in various activities). With regard to the meso level and related indicators of teachers' ICTs competence and teaching methods, a measure could be the number of teachers trained in the system. A qualitative measure could relate to the attitudes toward the use of ICTs and changes in attitudes of trained teachers

Putting the theory into the practice: Evidence from the field

Now I will present some evidence emerging from a case study carried out in Italy and shift attention from technology *per se* to the processes and skills that teachers and students currently apply. In doing so, I will connect data to the above-described framework, distinguishing among input, processes and outcome/impact indicators, specifically referring to the meso and micro levels.

The case study refers to the Cl@ssi 2.0 project, launched by the Italian Ministry of Education in 2009 within the Italian Plan for Digital School. Lasting 3 years, the project involved 156 classes of Italian lower secondary schools[4], on the basis of a voluntary participation, selected based on a

in International Mathematics and Science Study (TIMSS). For example, since the 2009 edition, the PISA survey explores students' use of technologies to learn, assessing their digital reading competences and their ability to navigate and evaluate information online, providing information on their use of computers both in school and at home (OECD, 2011, 2014a). Moreover, the Teaching and Learning International Survey (TALIS), an international survey examining teaching and learning environments in schools, asks teachers and headmasters about their work, schools and classrooms. In its latest edition the TALIS focused on lower secondary education level (OECD, 2014b); there is a specific section aimed to explore the use of ICTs in teaching practices (OECD, 2015).

[4] The Cl@ssi 2.0 project, in addition to the 156 lower secondary classes, involved 36 primary and 142 secondary ones.

project proposal to design an innovative teaching, technological and organizational model to be implemented. The Ministry of Education funded each of the participant classes with €30,000 to realize the proposed project to innovate learning environments through diffused use of technology in everyday school life (Schietroma, 2011). The general aim of the research was to verify the ICTs impact on educational processes and practices and analyzing the way in which they were used and how teachers and students reacted to that usage, in order to identify conditions and factors that shape the way ICTs are used in schooling (Campione et al., 2012).

In the next pages data collected from two different instruments will be presented. The first one is a monitoring quali-quantitative research tool, in the form of a logbook, administered online to teachers through the Cl@ssi 2.0 platform, in each of the three years of the project. The logbooks' goal was to collect documentary evidences on project stages, monitoring its implementation in each classroom and investigating whether, to what extent and how the use of technologies could have changed teaching and learning processes. Each logbook was structured into three sections, aimed at: i) gathering structural data on classes and information on planning project's step; ii) investigating timing and modalities of technological tools' use as well as the impacts on students' behaviors and relationships with classmates/teachers; iii) documenting teaching methods and performed didactic activities, gathering teachers' project evaluation. The sample consists of the classes that have filled out the three logbooks, which have been completed by the coordinator of the class council. The first one was compiled from 126 classes at the end of 2010 (response rate 80.8%), the second from 100 classes in the middle of 2011 (response rate 64.1%), and the third from 113 classes at the end of 2011 (response rate 72.4%).

The second research tool is a structured online questionnaire addressed to Cl@ssi 2.0 teachers, aimed at gathering information on their educational and professional career, the use of ICTs before the beginning of the project in classroom and in daily life, the opinions on educational technologies and their use in schooling[5].

[5] The research design has also adopted students' learning assessment before and at the end of the project trough INVALSI test and qualitative observation in some classes (see Campione *et al,* 2012).

Teachers' profile: ICT competences, professional development, orientations and beliefs on ICTs and schooling

The first data refers to the meso level to draw a picture of Cl@ssi 2.0 teachers' profile, their digital competence and educational and professional experiences. The following considerations refer to the 317 teachers consecutively involved in the project over three years; the teachers were interviewed via the online questionnaire. The sample reflects some elements of the Italian teachers profile, namely the prevalence of women in the composition of the teaching staff (women were 76% of the sample) and the high average age (more than half of the sample was 51–60 years old), with a long-lasting working experience in schools (35% of the respondents had taught 21–30 years, 32%, 31–40).

To explore the teachers' level of familiarity with ICTs, we investigated two different dimensions: the skills and use of tools and technological applications in their private daily life and in educational practices before the beginning of the Cl@ssi 2.0 project. In relation to the first dimension, more than 90% of the teachers regularly browsed the Internet in search of daily news and information about leisure activities. Moreover, 90% of respondents declared good skills and frequent use of the most common digital tools (i.e., email, programmes like Word) but the majority of respondents seem to be low skilled regarding Excel and PowerPoint. Social media didn't attract the sample. More than 75% of teachers didn't have an account in a social network or take part in forums, chats or blogs. A similar percentage didn't download music, videos or films.

With regard to the use of ICTs in educational practices before the beginning of the project, there emerged a prevalent use of the Internet to show students materials and documents, often employing the interactive whiteboard as a video-projector. In very few cases teachers reported involving students in the use of digital tools to produce content on their own or to search the Internet for information and materials. Similarly, more than 80% declared a scarce use of ICTs to share documents, favoring collaboration with other teachers (e.g., through mail, blogs and forums).

As the ICTs training, more than 75% of the sample declared having attended courses in the past 3 years, and 50% indicated such courses as their preference for future training courses.

All this information provides evidence to evaluate teachers' propensity as weak/little toward technologies, both in daily life and in educational activities. To try to better grab such propensity, we introduced in the survey

some questions aimed at getting teachers' orientations and beliefs on ICTs and schooling. So, among skills qualifying the teaching profession, more than 90% of respondents recognized the importance to efficaciously use ICTs. The opportunities provided by Internet and digital technologies were recognized unanimously. Those judged more relevant referred to information access any time and any place, outside of formalized space and time; to the opportunity to easily develop complex materials like videos, graphs, presentations, etc.; and to facilitate self-learning and the opportunity to better personalize teaching processes based on students' needs. Lastly, more than 90% of the sample believed that the use of technology could positively impact motivation, attention and engagement of students in classrooms activities.

Entering in the classroom: Processes and outcome/impact indicators

After drawing a profile of Cl@ssi 2.0 teachers, I explored the actual teaching and learning processes inside the classroom. The focus, therefore, was on the meso level, with particular reference to the learning environment, and on the micro level.

The first considered indicator related to the learning environment refers to the technological instruments used by the students because the project didn't indicate specific technological tools to purchase; each teacher could decide which instruments to buy according to the project's objectives. The most purchased technological tools were tablets, personal computers and notebooks (87.2% of the sample) and interactive whiteboard (73.8%); the less purchased ones were e-books, iPods/iPads and mobile phones.

Secondly, teachers were asked at the beginning of the project to evaluate the previous students' knowledge and skills in using such tools. Asking teachers the same question in the first two logbooks enabled to monitor the evolution of students' familiarity during the project. To do so, I created a 'familiarity index', starting from the variables indicating the number of students with different degrees of familiarity with the various technologies. I assigned a score to a 3-point Likert scale (*in no way* = 0; little = 1; *enough* = 2; *much* = 3). Then, the ratio between the sum of students per degree of familiarity and the number of students in class for each technology was calculated, obtaining an indicator of technological familiarity in relation to each tool. The final familiarity index, which can vary between a minimum level (0) to a maximum one (3), was obtained by calculating the ratio between the sum of the aforesaid indicators and the number of students in

each classroom. Data showed very low values referring to the interactive whiteboard and video-projector in the first logbook, indicating a generalized lack of student knowledge and skills in the project first months. During its implementation, the level of familiarity grew (higher values were in Northeast Italy, the lower ones in central Italy). Mobile phone and personal computers were fairly and adequately known everywhere. Cameras and photographic equipment, like learning objects, seem to be unfamiliar for students in all geographical areas. Similarly, the degree of familiarity with e-books was slightly null. Lastly, the smartphone is still little known, even if its familiarity level value increased during the project.

Focusing attention on the processes indicators, an increase among the three logbooks was registered in relation to the time tools were used by the students: from 2 hours daily in the first logbook to 4 hours daily in the last one, when no classroom reported using technologies less than 2 days per week. Generally, tools were used in the classroom with the help of a teacher, especially when they were employed by the whole class (more than 80% of the sample in all the logbooks).

By linking the used tools with the adopted teaching methods and the activities carried out in the classroom, data from the third logbook confirmed the previous findings. The interactive whiteboard, especially used for performing group work, seems to have been the best means of encouraging discussion and comparison among students, collaborative learning (facilitated by the use of video conferencing systems) and learning-by-doing activities, by proposing problems requiring the students' active participation for their solution. Group work also was carried out on the Internet (especially for research and information retrieval by small groups of peers), through the exchange of materials (audio and video) or through the use of specific discipline software. Finally, at the end of the project teachers reported having performed very rarely interactive lessons and to have used even less interactive educational games, confirming the trend emerged in the first two logbooks.

Referring to students' learning assessment modalities (Pandolfini, 2013a), 'traditional examination' (oral and written) seems to remain the prevalent form of assessment in many classes, confirming recent research findings collecting the opinions of almost 8,000 teachers across Europe (Cachia, Ferrari, Ala-Mutka & Kefala, 2010). In open-ended answers, a lot of teachers reported the use of technologies to evaluate digital/multimedia materials (such as podcast, video, hypertexts, blog) realized by students

individually or in groups and presented to their classmates, the occasional use of online surveys or tests and, less frequently, the use of an interactive whiteboard to carry out interactive exercises. The quota of teachers reporting use of technologies to perform class assignments increased from 40% to 67% during the project implementation.

Focusing attention on outcome/impact indicators, one aspect to be considered is the impact on classroom dynamics. More than 90% of teachers reported that ICTs had a positive impact on student attendance, behavior, motivation, attitude and engagement in classroom activities; ICTs also improved collaborative learning.

Data differentiating the two first logbooks refer to the competitive dynamics among the students. In the first logbook, ICTs seem to have promoted competition in 54.6% of classes, and in the second one in 28.3% of the sample. This likely is linked to the increased familiarity with the technological tools acquired by students over time or to the increase of collaborative experiences among students. In the beginning of the project, curiosity about innovative instruments and the desire to learn as quickly as possible how to use them through their regular use might have favored episodes of competition among students. In the following months, when likely everyone had gained a certain familiarity with the tools, such dynamics occurred less frequently. To this, it must be added that at the end of the project (third logbook), 53.3% of the sample reported that the project made difficult giving lessons. Some teachers explained that the use of technology slowed down the pace of implementation of educational activities and *determined problems in classroom management*. In particular, the use of an interactive whiteboard often caused *problems*, leading to situations in which students, allegedly *excited* and *enthusiastic* in front of the instrument, showed a greater tendency to get distracted and to compete with each other.

A final remark refers to the ICTs impact on students' academic achievement. Almost all of the respondents (95.7%) believed that the project improved just *more brilliant* student performance (i.e., those students achieving better learning results before the project). It is interesting to note that in some classrooms the use of technology seems to have increased the gap between the *better* and the *worse* students, so that a real improvement seemed to occur only in the first group. Moreover, third logbook's data highlighted some aspects that can be considered related, directly or indirectly, to student learning. For 93.5% of the sample, use of

the ICTs during the project limited the level of detail for the taught topics, and 77.5% reported a lower engagement in homework.

Final remarks: Learned lessons

The article proposed a theoretical framework aimed at providing multiple angles for the assessment of ICT impact in education, presenting evidence from an Italian case study. Now I will summarize some key points related to the diffusion of the technology-based school innovations and to the efficacy of indicators to assess ICTs impact in education.

The most important point learned from research in the educational ICT field is the complexity and multilevel aspects of technology-based school innovations. There is no single determinant factor: ICT adoption is a process dependent on the existence of a series of ingredients that are occurring in different degrees in each school, and hence different factors can serve as the limiting variable in the process of ICT adoption.

The factors that we can consider as particularly important prerequisites for successful ICT adoption and diffusion could be collected in a macro category defined as school-level barriers and referred to the meso level. It includes inadequate technological infrastructure (e.g., lack of access to ICTs, old devices), low Internet connections speedy (seen by some as unsatisfactory) and technical support (judged both inadequate and a major barrier to the development of ICT use in schools). Such findings are confirmed also by a recent research aimed at evaluating the investment of regional policy in digital technologies in Southern Italy schools in 2007-2013 (Giusti, Gui, Micheli & Parma., 2015). It highlights how several practical and organizational problems hinder the use of new technologies and digital services in schools.

Moreover, teachers' ICT competence emerged as second factor by importance. In most of the cases, the reluctance to integrate ICTs in educational daily practices was attributed to a lack of technical skills. For other schools, the barrier was perceived to be teachers' inability to see ICTs educational potential. This leads me to stress that the key factor is teachers' beliefs about ICTs and pedagogy**,** according to other recent findings on this subject (Pandolfini, 2013b; De Feo & Pitzalis, 2014). I'm referring to teachers' disposition (*habitus*), disciplinary culture and professional trajectories as formed during previous training and working experiences. It

is clear that the teachers' personal propensity and the cultural acceptance or rejection of ICT innovation play a key role, highly influencing the positive or negative results of innovative initiatives. Such differences among teachers make evident the dividing line between traditionalists and innovators, recalling a key issue in the sociological studies on teachers, i.e. the 'resistance to the change' (Besozzi, 2000; Ribolzi, 2002). The latter are teachers well disposed to welcome new tools or methods potentially changing their professional activities, while the former are less open to innovation and changes in their teaching processes and routines. In our research, those professionals enthusiastic about ICTs succeeded in using them despite inadequate infrastructure and institutional supports.

Other indicators referring to the meso level, in relation to both the institutional level and the learning environment, complete the picture. Leadership emerged as one of the key issues, with a number of schools reporting that the drive provided by school management facilitate to overcome difficulties. Secondly, the pattern of practice appeared as important because the crucial variable seems not to be the device but the method employed; the same technology, in the hands of different teachers, produces different outcomes. Thus, according to other studies (Giusti et al., 2015; Gentile & Pisanu, 2012), most of the changes were attributed to the student-centered method, than to the technology centered one.

Thirdly, referring to the collaboration indicator, an main factor was the presence among the staff of an ICT champion, often a keen ICT enthusiast and a supporter of colleagues to the extent of providing direct training for them. This is reminiscent of Rogers's (1964) classical model of adoption of innovations: because it is difficult to involve all teachers in the innovation process at the same time, a gradual strategy could be adopted, which first involves those who take up innovation, often called *early adopters*.

Finally, the case study highlighted the importance of contextual factors, clearly showing how innovation is context-dependent. Therefore we should bear in mind the necessity to reflect beyond pure observations and evaluate more concretely institutional contexts of learning as well as learning situations and teaching processes to determine under which circumstances ICT-based activities can enhance learning and improve skills. So, as partly stressed also by the OECD review of the Italian Strategy for Digital Schools (Avvisati, Hennessy, Kozma & Vincent-Lancrin., 2013), to better understand technology-based school innovations, it is important to consider not just internal school characteristics but also external environment in

which each school is embedded (referring, for example, to what some interviewees called 'the lack of an innovation culture' at a local level).

The contextual factors in the Italian study emerged at three levels, producing gaps first among regions (North, Centre, South of Italy); next, between schools in different urban areas within the same region (low- to upper-middle class, etc.); and finally, inside each school, between different classrooms. Thus, if an innovation occurs in a context deeply marked by inequality, it unlikely will eliminate inequalities; rather, it will bump into a risk of patchy innovation (Campione et al., 2012), also itself producing new inequalities.

In relation to the definition of a set of indicators, this article reflects on the ways to assess how ICTs are used in schooling and their impact on different levels. The interest in such topic has emerged from the awareness of the risk of reducing the complexity of the impact of ICTs on our education system, only seeing a part of the picture, without understanding how things are interconnected (Erstad, 2009). Defying such set of indicators absolutely is not an easy task, and policymakers as well as researchers usually run into difficulties, requiring careful methodological considerations. Here I will recall just few of them, connected to the presented case study.

One problem is related to self-ratings because teachers were asked to rate their own ICT competences. Although such measures may be fine as indicators of self-confidence, they often are used as proxies for real competences. Such use is unwarranted as self-ratings are prone to bias (Ross, 2006). A second aspect, referring to the qualitative indicators, is related to teacher perceptions because we collected data on perceptions of teachers regarding the ICTs impact on, for instance, students' motivation and skills. The validity of such measures is highly questionable and the ratings are prone to wishful thinking. Hence, such measures should be used only as an indicator of teachers' attitudes toward ICTs; similar consideration could be done in relation to the importance recognized to digital skills to qualify the teaching profession, i.e. 'subjective' evaluation. On the contrary, the research highlighted a weak teachers propensity toward technologies, investigated analyzing the actual use of them (i.e. 'objective evaluation') both in daily life and in educational activities.

A third aspect is related to 'improved or new teaching and learning process'. Having an 'objective' measure of an 'improved' process could be very difficult as it would require a clear definition and measurement of all

the different aspects affecting this process, including the always fuzzy concept of quality. However, a 'subjective' evaluation of the changes in the process by the stakeholders (teachers in our case) could be a way to get around this initial difficulty (Scheuermann & Pedró, 2009). Such considerations lead us to stress that in the indicators' construction process a strong methodological accuracy is recommended, 'indicators are inevitable approximations. They are not the same as the desired change, but only an indicator of that change. They are imperfect and vary in validity and reliability' (Patton, 1996, p. 59).

Another point I would like to stress is the necessity of enhancing knowledge and skills about indicators of ICTs impact on education among the school staff, integrating top-down and bottom-up actions through a timely and authentic involvement of all stakeholders, such an approach is often neglected. The indicators approach often reflects the wider top-down, or outside-inside, mentality that was adopted through the implementation of massive programs and reforms. In a way, there is a consistent part of a wider top-down policymaking culture which assumes that the starting points for generating school change are the actions of policymakers (Kollias & Kikis, 2005). On the contrary, I think that only the school staff involvement could guarantee a real sharing of aims and methods, avoiding a mere top-down direction, unlikely comprehended and accepted by schools (*in primis* by teachers and headmasters, but also by students and their families). Moreover, just the living actors who each day embody ICTs inside the classroom could provide a real added value toward a more comprehensive understanding of technology-based school innovations, until its monitoring and assessment.

A final remark is linked to the assessment of the ICTs impact on students' academic achievement, a field of research interesting a growing number of scholars. The issue begs further questions of what, nowadays, is valued in education: only those skills that are measured by national and international standardized assessment or other types of skills? The main references on such topics are the so-called 21st century skills (Binkley et al., 2010) and the key competences for lifelong learning such as sophisticated thinking, flexible problem solving, collaboration and communication skills youth will need to be successful in work and life (European Commission, 2007).

I think that new standards, defining what student should be able to do, must replace the basic skills and knowledge expectations that profiled the

'traditional' student and so new conceptions of educational assessment are a key strategy for accomplishing the necessary transformation. Technology could serve as both a driver and lever for such transformation. The question is: to what extent do ICTs enhance or change these skills and their measurement? A paradox seems to arise: while the technology encourages students to pursue personal interests (for instance, customization of learning enhanced by new media) this comes into conflict with the standardized assessments that pervade schools. Current work on assessments in this field seem to be limited to digital literacy. There is a need to expand the use of technology for literacy to other areas, and a focus on both formative and summative assessment should be upheld. Also in relation to digital competence, specific definitions of competences should be developed, and appropriate tests should be put in place to measure and evaluate the achievement of these (Ferrari, 2012).

To conclude, there is a need for more analytic concepts and research tools helping to grasp the complexity of the matter, toward a systematic and multilevel approach. The existing theoretical and empirical studies provide a good basis for going one step further, but more international cooperation on lessons learned in each single case study or project is needed, enabling teachers, headmasters and policymakers to make sound decisions when they face opportunity for investments in ICTs.

There are still unanswered questions about the impact of technology in short- and long-term learning and how it affects simple and complex learning tasks. In particular, research on ICTs may explore new fields (e.g., neuroscience) such as the effectiveness of multitasking and the impact of ICTs on concentration (Bocconi et al., 2013).

From a sociological point of view, there is the need of a better understanding of the interrelationship between different levels and how each of them might strengthen or hinder changes within educational organization (Erstad, 2009). To this aim, the Italian study shows the importance of performing more qualitative action research and to adopt an observation-based approach, entering the schools culture and speaking with the main actors involving every day in the educational practices, going beyond the mere infrastructure and access to technology-based indicators.

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