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Education and Digital Transformation: The "Riconnessioni" Project

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ABSTRACT Schools, universities, and other educational entities are increasingly aware of the untapped potential of digital transformation, an essential process for increasing efficiency and collaboration, and reducing costs and errors in the management of at-scale training systems. In this context, the "Riconnessioni" project was promoted by the Compagnia di San Paolo in agreement with the Ministry of Education but planned, started and developed by the Foundation for the School. The digital transformation started with a defined strategy that leveraged opportunities presented by new technology while meeting the objectives of system stakeholders. Through several steps, that strategy was developed for education connecting everything to support tomorrow's digital world and creating strong strategic partnerships able to build an ecosystem connecting people, processes, and things into a powerful, secure, and smart communications network. This paper reports on the three-year Riconnessioni project, which is combining the energies of teachers, managers, administrative staff, students, among others, and experimenting with new learning models, taking advantage of opportunities that emerged from perceptions stemming from concerns and systemic issues. To date, more than 150 schools in Italy have been included in the project, together with 550 teachers selected to scale up the instructional process. Using a methodology called "cascade training", the 550 selected teachers were able to spread the knowledge to more than 2,600 colleagues. The monitoring and evaluation activity performed in Riconnessioni aims at processing information on implementation and results, following three lines. First, it regularly evaluates project activities from a reporting standpoint. Second, it verifies the plan consistency against implementation achievements. Third, it identifies changes produced and focuses on teachers' and students' skills to evaluate the effects of the project. The assessment framework is also discussed in this work, reporting on results regarding feedback, follow-up, and effects gathered from the field. The evaluation highlighted that labs were indeed able to improve teachers' competence and underlined the added value of cascade training which spread digital domain knowledge and awareness into the group of involved schools.

INDEX TERMS Digital transformation, adaptive learning, computational thinking, computer science, education, information technologies, primary school, secondary school.

I. INTRODUCTION

Schools, universities and other educational entities are increasingly aware of the urgency and untapped potential of digital transformation, an essential process for increasing efficiency, increasing collaboration and reducing costs and errors in the management of education and training systems at local, regional, and national levels [1].

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Gartner's 2018 report [2] makes predictions about top business-tech trends using the concept of intelligent digital mesh to depict "the entwining of people, devices, content and services" that will be the foundation of the "next generation of digital business models and ecosystems". The following categories derive directly from the terms used in that concept:

- *Intelligent*: this refers to how Artificial Intelligence is percolating into every technology, becoming the root of more dynamic, flexible, and autonomous systems.

- *Digital*: this entangles the real and virtual life of an entity to create an immersive digitally enhanced environment where the profiles of all things and concepts are often linked in some way.
- *Mesh*: this refers to any connections among services, people, business, and devices, able to deliver any digital representation.

Education often comes after the business world in using the potential created by new technologies. There are a few relevant bright spots in tech trends in the business world that have had a positive impact on education [3]. Virtual classrooms and apps for learning are on the rise, and collaborative learning and constant updating of teachers' skills are new developments that have already effected changes without precedent within a non-negligible part of the education system [4].

However, integration of technology into classrooms requires competence and confidence, still lacking in a context where close to 60% of teachers report a need for professional development in using ICT for teaching, according to the OECD (the Organisation for Economic Co-operation and Development) [5]. A teacher, or anyone else for that matter, cannot become an expert in a few hours due to the pedagogical, technological, and content knowledge required to address students' contexts and learning domains. Additionally, teachers' attitudes toward technology play a primary role in the process [6].

Furthermore, demography may have a broad impact on resilience to change as shown by the Italian education system. According to the Eurostat-2015 report, in the first group of countries composed of Belgium, Croatia, Luxembourg, and Malta, the proportion of teachers under 40 was over 40% at each teaching level. A second group, including Italy with Bulgaria, Greece, Latvia, and Lithuania had a proportion of young teachers under 30% for the three teaching levels. Italy stood out with about 10% of teachers under 40 at each ISCED (International Standard Classification of Education) level. A third group composed of Finland, France, the Netherlands, and Slovenia, had a concentration of older teachers at ISCED 3 (75% were over 40) and relatively young populations at ISCED levels 1 and 2 (about 40% of teachers under 40. Furthermore, according to 2017 data, got from the same source, more than half of teachers (53%) reached the age of 50 in Italy and, moreover, close to 78% of the primary to upper secondary school teachers are women [7].

Another issue is how technology can help "talk"' to the community so that it can be leveraged for more effective interaction with parents and students. Examples of such practices are text messages sent to parents to engage them in children's learning by informing them of missed classes, interacting with students to give them career guidance and other relevant tips, and "mindset messages" to help pupils have positive attitudes. For teachers and school leaders, using technology, such as platforms and social networks, ensures both that parents have access to information and news about their children and especially that the information is transmitted to parents regardless of their marital or immigration status.

However, many institutions must still adapt the main administrative processes and corresponding activities underlying their operations. Most of these daily activities, from enrollment of students, to purchasing requests, to requests for notification of absence, still involve processes that rely on paper or e-mail, which reduces systemic flexibility and incurs great cost in terms of time.

New tools and digital technologies, such as generalized interaction platforms, can help schools automate internal processes, simplify routine tasks, and improve communication among students, faculty, and parents. These changes lead to significant improvements in efficiency, which can in turn change the behavior and daily activities of all actors. They can also represent fundamental difference from tradition, allowing educators to focus exclusively on students rather than on the day-to-day drafting and management of documents.

Given the complexity arising from this context, digital transformation needs a model to pursue an organized domain where actors can make plans to improve the education ecosystem.

The OECD Education Systems model [8] is increasingly serving as a reference in the organizational area since it proposes to evaluate the performance of national education systems as a whole rather than compare individual institutions or other territorial entities. However, there is increasing awareness that many essential properties of the development and impact of education systems can only be measured through understanding learning outcomes carried out through recognition of their relationships to inputs and processes at the level of individuals and institutions.

Hence, the first dimension of the organizing framework distinguishes three levels of actors in any education system [9]:

- *education systems as a whole*, including the social context in which they exist; as a result, there must also be reference to economics and demographics associated with political perspectives;
- *providers of educational services*, such as schools and other institutions, as well as the educational setting within those same institutions, focusing on classrooms and teachers;
- *individual participants in education and learning*, who are primarily students.

Table I and Table II report some of the expected opportunities resulting from new tools, learning methods, and digital technologies, as well as obstacles to achieving digital transformation in the education system.

By comparing opportunities and obstacles, it emerges that the future of technology in education is not technology but predominantly leadership skills. The transformation process must be initiated from above; that is, it must be stimulated by the same Scholastic Director and by the Institute Council over which he presides. It is crucial that the latter understands the

TABLE 1. Opportunities deriving from digital transformation in the education system

Opportunities
Access to information: digital technologies and connectivity allow access to information that is ample, immediate, updated continuously and fair. Digital archives, institutional sites, databases, magazines, and other publications can be browsed with high effectiveness in the chrono-topological domain, compensating for any shortage or absence of books in families, schools or even cities.
Availability of content: the digital environment is able to adapt the access to the information to the needs of the user, such as special needs, cognitive and motor disabilities, and linguistic limitations. One example of this is digital children's literature: in fact, digital stories can use synchronized symbols, video and audio and images in movement, a favorite communication channel for girls and children with special educational needs or disorders on the autism spectrum [10]. The experience of reading a digital story can be customized to the rhythm and needs of the user: for example, it is possible to increase the distance between words, syllables, and letters and increase the font size to better identify the words, to changes the background/font contrast or to add a mask for reading. The use of audio and symbolic aids enables better understanding of the text. Finally, it is possible to group extended periods into semantic units highlighting the punctuation to enhance differences in narrative times. These tools, developed for users with special needs, can be valuable for anyone, especially those seeking to understand a written text for the first time
Creativity and digital production: digital approaches allow customizing not only the use of content but also its creation. Teachers can now create ad hoc materials suitable for their classroom context without needing a print shop and in a short time. Moreover, the creative process and the consequent realization of a product are facilitated by the vast world of applications that gradually guide the teacher, instructing him step by step in the creation of movies, "stop-motion" videos, illustrations, and interactive games. This content can be realized in a reasonable time with devices of everyday use and does not require the acquisition of specific and highly complex equipment.
Collaboration and sharing: digital technologies enable schools to become creative labs, where a community of students can acquire first-hand experience, search for content, collaborate in problem-solving, and implement projects. In virtual and nonvirtual environments, students can work together while being in different places, expressing themselves in real time, sharing opinions and having discussions with each other. In a connected classroom, global boundaries disappear: teachers and students can connect, communicate, compare, and collaborate with others who are geographically and culturally remote. A school class that can communicate with others who are far away has the opportunity to learn about differences and the news and cultural and social needs of the entire world.

value and urgency of the transformation and how it can be shared by all the parties involved. Leadership must support the use of technology and almost insist on guiding the institution in the use of technology everywhere: from social media to learning environments and from the electronic register to the library.

There is no doubt that e-learning, the several online courses launched, and "one-to-one computing" [9] are changes having a high systemic impact. However, we must not neglect the back office and the enormous benefits of digital transformation to services supporting the overall administrative system.

Four digital transformation actions have significant systemic impacts:

- *Eliminating paper*: paper processes are omnipresent in all institutions, not just educational ones. Schools and universities use a considerable amount of paper routed through numerous departments and hierarchical levels of control and management. As is known, the elimination of paper offers significant advantages and creates incredible new digital experiences for all actors, being, in fact, the first and simplest step of digital transformation.
- *Automating processes and operations*: considering the speed with which technology affects organizations of any size in all administrative domains, it is evident that educational institutions that do not embrace digital transformation will inevitably be left behind in the coming years. High costs and constrained budgets exert extreme pressure on the modern education system; as a result, it must invest in operational excellence to compete in an environment that has already transformed over the years, promoting the widespread automation of flows.
- *Using mobile devices*: smartphones are the platform of choice for "millennials". Food, taxis, houses, assistance services, and professionals for domestic activities can be identified, booked, and ordered using a mobile phone. Mobile phones are the most popular vehicle for change supported and promoted by the Internet revolution. In schools, end users have grown up with cell phones, and today they are the most immediate means of interaction.
- *Using the cloud*: the cloud is a fundamental component of the life cycle of digital transformation; it lays the foundation for the digital revolution in any organization. The processes provided by the cloud are essential to enable mobility and speed and bridge the skills gap. Cloud service providers have accumulated years of experience and made significant investments in providing reliable, scalable, and secure solutions that offer agility, efficiency, resiliency, and cost optimization.

This work describes the "Riconnessioni" project [11], promoted by the Compagnia di San Paolo and planned and started by the Foundation for the School. It reports on the state of the art and the progress of the work, also describing how it has been oriented to operate systematically toward adequate acceleration of the innovation process, in a context with variable dynamics of complexity and scalability.

Riconnessioni has among its objectives that of engaging younger teachers to enforce the innovation attitude of the education community, working with them directly to shape sustainable innovation processes.

Apart from reporting the detailed description of the Riconnessioni project, this paper aims at:

- Providing some guidelines on how training initiatives devoted to improving teachers' digital competences could be structured/organized;
- Evaluating the impact of training initiatives on teachers' competences;

TABLE 2. Obstacles to digital transformation in the education system

Obstacles
Resistance to the use of new technologies and new systems: the adoption of a new technology or system induces insecurity and resistance to acquiring new skills or understanding new processes. It is necessary to operate in such a way that employees/users clearly understand the advantages of these changes. Three main factors in schools have been determined to significantly influence teachers' use of digital technologies and changes in education. • Leadership: relates to the school principal. How a principal ranks digital technologies is the most influential contributing factor to teachers' involvement and related student-centered pedagogy. • Shared group vision: relates to having a clear idea of how digital technologies can be used. Teachers should lead their classes in creating this "shared vision" so that the teachers are more likely to feel invested in technology use and change, helping develop a school culture of change via community activities. • Support for change: the principal is also responsible for providing the necessary technological support for learning about and using digital technologies and even adding pedagogical support for incorporating student-centered practices.
Attracting talent: skills are at the heart of innovation. The lack of resources or skills has emerged as the greatest challenge to digital transformation. Educational communities must be able to compete to acquire talent, which today is not very present in a variety of sectors, including the experience of user interaction, security issues, and the cloud infrastructure. Principals should also emphasize the importance of teacher evaluation to enhance classroom practice, recognize teachers' work, and help teachers, schools, and the entire education ecosystem identify professional and organizational development opportunities. This goal can also be pursued by including in teacher evaluation self-evaluation, informal peer evaluation, and classroom observation. Principals and other senior colleagues should also be trained in evaluation processes, and schools should have plans and the resources to meet identified needs in teachers' professional development. Additionally, using teacher evaluation to reward teachers for exemplary performance with faster career progression, sabbatical periods, opportunities for school-based research, support for postgraduate study or opportunities for in-service education could provide prospects for systemic growth.
Integration of existing systems: existing systems, although obsolete, are nevertheless fundamental for supporting the evolution of a school's organizational processes. However, new web-based business applications are not necessarily compatible with old processes. This weakness is a major obstacle that organizations encounter as they are also forced to invest additional resources, difficult to find, in personalized updates or integration. Instead, once schools have access to educational technologies, enhancement of technology integration often improves technology use in ordinary learning and management activities. Nonetheless, ordinary experience and literature suggest that even when operators and students have gained access, they do not always use technology for learning process enhancement [12], [13]. Social and moral ethics, like the question of unequal access to technology among students, delays technology use scaling in schools. Consequently, some teachers avoid requiring students to use technology to complete their homework. Moreover, many schools restrict use of various techniques due to potential ethical issues and other concerns, considering it their duty and a moral imperative to check students' Internet access and supervise their Internet use. Most schools invite teachers to participate in professional improvement activities, where the most common goal is to change teachers' attitudes toward technology integration, also reinforcing their ability to use specific technologies. A significant issue in these efforts is that, in most cases, they do not focus on practices that are both contextually and pedagogically sound at the same time.
Start of transformation: defining where a process of transformation should start is a critical challenge as it is necessary to translate strategy into a concrete action plan. It is necessary to identify a process that is neither too simple nor too complicated, has a reasonable volume of informative impact, and is easy to evaluate in terms of time for planning and human resources necessary to transfer it to the digital domain. Digital transformation in the education context should start with a strategy that leverages the opportunities offered by the new technology while pursuing the objectives of the reference stakeholders. It includes the following four steps: • Connecting everything to support tomorrow's digital needs; creating strong strategic partnerships and building an inclusive ecosystem able to gather people, processes, and things to create a cyber-physical network supporting high capacity, as well as being secure and smart. • Deploying analytics to enhance automation and awareness and save money using real-life experience and real-time data to drive strategic initiatives that increase performance, spreading out transformations. • Rolling out new business models, taking advantage of the Internet space whereby essential services are provided free of charge while only more advanced features must be paid for, thus promoting cheaper on-demand services, which are more flexible and more straightforward to manage than traditional systems. • Moving toward a unique, simple platform, whether it is on-premises, in the cloud, or a hybrid; the critical purpose of digital transformation is to deliver a single platform as the establishment of a robust network and communications infrastructure.
Data analytics: in education, learning analytics is the term used to address big data used to improve learning processes. Analytics have not yet had the impact on education that one might expect, considering their impact in other domains. Regardless, a change is in progress since educators, researchers, principals recognize the value of data in refining both learning and schools' organizational profiles, improving the quality of education and overall competitiveness. Some research communities are developing promising models for improving learner success through the use of predictive analytics, machine learning, and network analysis, also tracking the development of concepts through social systems.

- Evaluating the applicability and effects of "cascade training", a mechanism empowering teachers with the task of spreading knowledge to their colleagues.

To evaluate the appropriateness and the impact of training initiatives, as well as the effects of cascade training, several questionnaires have been provided to teachers, and a survey on teachers'/students' competences has been carried out (the survey is the first out of two evaluations, since the second one is expected to be carried out at the beginning of 2021).

Fig. 1 reports the holistic picture [14], [15] of the Riconnessioni project, described as a composition of five major phases. The first phase deals with the *improvement of the existing infrastructure* and has been planned to strengthen the fiber-optic backbone together with the internal connection framework for school buildings.

The second phase is devoted to *teacher and school staff training* and is built around several labs and workshops on topics related to, among others, new technologies, innovative teaching approaches, digital content. They are attended by teachers and school staff from involved schools.

In the third phase, *cascade training*, labs attendees were in charge of spreading knowledge and lessons learned during the training to their colleagues, thus increasing knowledge and competence of the whole school.

In the fourth phase, *innovative classrooms* are expected to take place. In such classrooms, teachers use their acquired knowledge and expertise to plan and deliver innovative training modules to their students. A similar process takes place for school staff, managers included, which exploit their competence within ordinary administrative tasks.

The last phase is devoted to *monitoring and evaluation*, which foresees periodic analysis and reflections concerning carried out activities on assessment. The right side of Fig. 1 shows how the different phases are related to each other, reporting the outcomes of each phase in italic text.

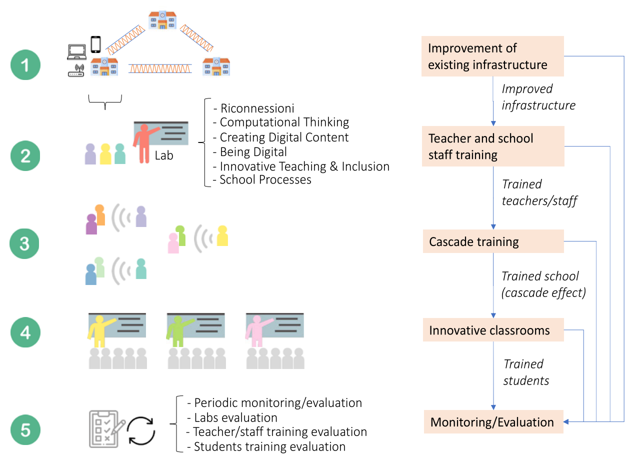

FIGURE 1. Riconnessioni project holistic picture.

It is worth remarking that phases two, three, and four are sequential since each one of them is based on what has been performed in the previous one. Phase one is a prerequisite for the subsequent phases, even though teachers and school staff training could be performed in parallel to this phase. Phase five is transversal to the other phases since the evaluation is performed at the end of each phase.

In the following, the Riconnessioni project is presented. In particular, this paper describes all the activities planned from phase one to five. The ones devised for stages three, four and five are currently still ongoing.

The paper is organized into six sections. The following - section two - introduces previous results on the subject found in the literature and similar experiences used as references during the early development phases of Riconnessioni. Section three focuses on the project framework addressing the layered digital transformation model, including infrastructure and devices *(phase one)*, training teachers and school heads, and teaching and learning process management *(phase two)*, also focusing on system scaling approaches *(phase three)*. Section four introduces the monitoring and assessment framework *(phase five, with some information on how monitoring and assessment is/will be performed in phase four)*, while section five presents and discusses the results gathered in terms of feedback and follow-up *(phase five)*. Finally, section six reports on conclusions and future work.

II. LITERATURE REVIEW

Digital transformation in education involves many different issues, from infrastructure, organization, teaching/training, learning, content, and tools to economics, environment, security, and privacy. These are many facets in a composite kaleidoscope; they can be researched in the literature but are addressed often from separate independent perspectives and rarely with a holistic view of the entire system's complexity.

Several researchers have hypothesized about what the school of the future will look like [16]–[18]. According to the authors of the above papers, future classrooms will have a multiscreen display, wireless Internet access, and lab simulators; will use smartwatches and mind recognition devices; and will combine virtuality and reality to support teaching and collaboration. Research initiatives have already begun to design innovative solutions, e.g., based on virtual reality [19], [20], and to design innovative ways of teaching and evaluation of students' competences [21]–[26].

Regarding the introduction of new technologies in schools and the modification of existing training programs to improve/innovate the existing training offerings, several projects have been carried out. CAS has made a significant contribution to digital content; in fact, Computing At School [27] promotes the introduction of computer science in school curricula. Its aim is to pursue "computing with computer science at its heart, to become firmly established in all primary and secondary schools, alongside mathematics and the natural sciences", also supporting "all teachers committed to providing high-quality computing education" in their classrooms. In the EU, the organization Informatics Europe has promoted Informatics for All [28], [29], a program devised jointly with ACM Europe. The initiative's purpose is "to give due recognition to Computer Science/Informatics as an essential foundational discipline for education in the twenty-first century".

The PP&S Project [30] (Problem Posing & Solving) is part of the initiatives promoted by the General Directorate of the Ministry of Education, aimed at supporting innovation in primary and secondary education. A national survey on the school system, developed as a premise, highlighted specific concerns and issues, such as:

- weaknesses in addressing problems in quantitative terms;
- an almost exclusively disciplinary nature of the training system;
- the prevalence of a cognitive approach rooted in a deductive approach moving from the general (theory) to the particular (practice), built around applications, too often confined to an ancillary role;
- the loose correlation between school education and cultures of the labor market, resulting in a perceived delay in terms of the impact of computer science on the content and organization of training activities.

The PP&S project was carried out from a careful analysis of the OECD PISA [31], including the results obtained at the international level and from the INVALSI (National Institute for the Assessment of the Education and Training System) [32] national surveys. The latter clearly demonstrated the need for strengthening mathematics learning, suggesting actions responding to the needs expressed by schools engaged in implementing the second cycle secondary reform.

The project, focused on the problem-solving methodology, intends to exploit the innovative potential of information technology as a key to innovation by scaling access and sharing of experiences and practices within an ad hoc community. The impact on scientific application domains (physics, chemistry, natural sciences) is immediate, and there is potential for innovation in all disciplinary areas, including socio-humanistic ones.

Despite the efforts made in the above initiatives, it must be emphasized that redefinition of the existing training offers must consider teachers' skills and competences, as teachers are the subjects in charge of carrying out the training itself.

In this view, a significant portion of the existing worldwide literature addresses analysing teachers' competences and investigating how they exploit emerging technologies in their classrooms, with the objective of sharing lessons learned with other trainers.

In [33], the ICT experience of some Ugandan educators is analyzed. In particular, this work reports how educators exploited digital resources to improve pedagogical practice and analyses the challenges faced by educators during the use of ICT. Not surprisingly, the authors find that inadequate training of educators is a barrier to use of ICT in classrooms. Interestingly, the paper identifies other barriers that threaten the success of ICT initiatives related to Internet connectivity, power outages, and culturally irrelevant material.

Other barriers related to teachers' training are analyzed in [34]. The authors of this work report on recent changes in Brazilian Institutional Policies on teacher training. In particular, Coelho and Grimom start from the proposition in [35], that teachers' development has two dimensions: personal and organizational. The authors of [34] emphasize that teachers' professional development does not only involve training; it also requires adequate work conditions, motivation, and reflection on teaching practices.

Similar assertions are made in [6]. This paper addresses the creation of a life-cycle efficacy framework for educational technology. In particular, the paper stresses that successful implementation of educational technology requires teacher training and interest. The same idea is earlier expressed in [36], which states that educational technology can successfully support learning and improve productivity only if stakeholders believe in the necessity of the technology, are trained in its usage, and display technology leadership behaviors through technology usage. Hence, the framework presented in [6] is composed of five stages, namely, *strategic planning and procurement*, *implementation and comprehensive assessment*, *communication and transparency, stakeholder feedback, and re-evaluation*.

A successful initiative is mentioned in [37]. This paper reports the experience of a U.S. teacher using digital storytelling in her classroom. In particular, the teacher received specific training on how to teach and engage students with a specific software application and was required to identify inventive lessons that could benefit from the technology, as well as how to integrate the technology to support teaching effectively. In this view, the teacher was directly involved in reflection on how her training could be adapted to include (and could benefit from) ICT.

Concerning improving trainers' competences, in [38], a Chinese experience is described. Specifically, this work presents a platform for teacher training. A common problem recognized by the authors is that teachers are rarely able to participate in training activities and share their teaching experience with other teachers. Hence, one of the platform's aims is to foster discussion and interaction among teachers. Another work describes a similar platform, targeted to teachers in Mexico [39]. A key aspect of such a system is the rewards system, which has been designed to recognize teachers' results (with a view to fostering teachers' motivation).

The paper [40] reports an Israeli experience related to microlearning. In this experience, teachers were able to improve their competences by attending online courses structured in small units. Another Israeli initiative is described in [41]. Here, the authors take a step forward concerning the works cited above, by describing in detail a workshop entitled "Methodology of Computer Science Teaching", part of a program to obtain a Teaching Certificate in Computer Science (hence, this work provides some practical information on how to successfully train teachers in ICT-related topics). The workshop focuses on basic topics related to computer science, problem-solving methods, misconceptions, recursion, algorithms, and teaching and learning strategies, as well as assignments/exams and inquiry-based learning.

A different interpretation of ICT-related training courses for teachers is reported in [42]. This paper summarizes the experience of teaching with ICT in the Norwegian educational system (a country in which teachers are among the most digitally competent compared to colleagues from other countries [43]). In particular, the paper starts from existing models to describe the knowledge and skills required to successfully integrate digital tools in a learning environment (mainly technological, pedagogical and content knowledge [44]) and proposes a different perspective. This perspective shapes a teacher's digital competence in terms of *teaching of*, *with,* and *about ICT*. The teaching of ICT aims at increasing students' digital competences (i.e., learning to use technology). The concept of teaching with ICT instead is about using digital technology to achieve added value in learning (i.e., use the technology for learning). Finally, teaching about ICT has a broader meaning and includes topics such as the history of technology and the relationship between technology and society (i.e., critical reflection on technology).

Another interpretation of ICT-related skills is presented in [45]. This work enumerates a set of skills that young people will need in the new media landscape. Such skills include, among others, the abilities to experiment with one's surroundings and perform problem-solving (play); construct dynamic models of real-world processes (simulation); select and remix media content (appropriation); scan information and focus on relevant details (multitasking); interact meaningfully with tools to expand mental capacities (distributed cognition); collect knowledge and share it with others to achieve a common goal (collective intelligence); evaluate the reliability of an information source (judgment); search, synthesize and disseminate information (networking); and discern and respect multiple perspectives (negotiation).

As noted in [33], digital transformation should not only address educators' training. It should also involve initiatives aimed at improving the existing infrastructure.

In this view, an exciting project addressing infrastructure establishment is represented by EducationSuperHighway [46], the leading nonprofit organization focused on upgrading Internet access in every public school classroom in the U.S. It has firmly advocated since 2012 that digital learning has the potential to provide all students with equal access to educational opportunities and that every school needs high-speed broadband to transform that opportunity into experienced reality. It has helped school districts and state leaders develop strategies to upgrade their K-12 networks, bring fiber to schools, provide guidance for appropriate Wi-Fi purchases, and make broadband more affordable. It claims [47] its work catalyzed the modernization of the Federal Communications Commission's financed program.

Regardless, only 30% of school districts in 2013 met the Commission's minimum Internet access goal of 100 kbps per student. This situation left approximately 40 million students behind without the bandwidth needed for digital learning. In 2015, more than 75% of school districts, representing close to 60% of schools, and 53% of students met the minimum Internet access goal. These data suggest that the number of students with Internet access increased by 20.5 million, more precisely growing from 4 million in 2013 to 24.5 million in 2015. EducationSuperHighway has also increased the number of teachers with the broadband access needed to deliver a 21st-century education, increasing from less than 300,000 in 2013 to 1.7 million in 2015.

The 2018 report [48] states that 98% of U.S. public schools have next-generation fiber infrastructure and 96% have enough Internet connectivity to make digital learning available in their classrooms. In 2018, at the beginning of the school year, 40 million more students had high-speed broadband in their classrooms. However, work is still in progress since the remaining 2.5 million students and 1,300 schools still need the necessary infrastructure.

The Plan Ceibal in Uruguay [49] is another exciting project, which in 2009 began a "One laptop per child" initiative to sustain the Information and Communication Technologies (ICT) in primary public education. It subsequently expanded into secondary schools, and today Plan Ceibal has achieved results in many cultural domains since it has increased equity in access to devices and the Internet and access to platforms that improve learning, such as the digital library and the study of English, mathematics, robotics, and programming.

In four years since 2007, Plan Ceibal [50] delivered 450,000 laptops to all students and teachers in primary education, also planning no-cost Internet access throughout the country. As of 2009, the results included increased self-esteem in students, improved motivation in students and teachers, and active participation by parents, 94% of whom approved of the plan according to a 2009 national survey.

The success of Plan Ceibal was not measured in terms of technological innovations but mainly in terms of achievements such as training plans for teachers in primary education, active inclusion of the entire society and the successful design of a monitoring and evaluation model to measure the impact of the project to inform future actions. Plan Ceibal emerged as a consequence of the digital gap existing in Uruguay between people with and without access to technology. The project was inspired by Nicholas Negroponte's One Laptop per Child project addressing three principal values: technology distribution, knowledge promotion, and social equity improvement. Finally, "Jóvenes a programar" ('Youths in Programming') began in 2017. Its goal is to expand the work competences of 1,000 young people between 17 and 26 who are outside the education system by teaching them programming skills. Within this context, the Ceibal Digital Library has been relaunched [51], now also equipped with interactive features allowing the digital community free use of the library catalog from any device.

Concerning the above work and initiatives, the objective of this paper is to report an Italian experience related to digital transformation. In particular, in this work, everything is influenced by the reflections in [6], [33]–[35], [37], [38], [42], [45] and addresses multiple aspects related to digital transformation.

As suggested in [28], improvement of existing infrastructure is considered a vital aspect of the success of the initiative.

The structures of five labs targeted to teachers and one targeted to school administrative staff are also described. In particular, lessons learned reported in [6], [35] are also considered, and particular attention is given to the involvement of school administrative staff to ease organizational change (as suggested in [6]). Stakeholder feedback and evaluation are also carefully considered.

To determine the content of the labs for teachers, the assertions in [34], [37], [38] establish the starting point, and particular attention is given to promoting interaction among teachers [38] and their involvement in suggesting how technology can be included during lessons to foster learning [37] as well as moments of reflection [34].

As presented below, the designed teacher workshops included in all of the labs address digital competencies identified in [42]. In fact, the workshops provide teachers with competences in computational thinking and coding (*teaching of ICT*), address the issue of exploiting technology for the creation of advanced educational material (*teaching with ICT*) and include reflections on the relationship between society and technology, as well as on the use of technology for cultural inclusion and support for students with special needs (*teaching about ICT*). To develop the lab content, the previous experience of the authors of [36] is used as a base extending the set of skills provided to teachers, also enhancing the various workshops planned for the labs. Furthermore, during the development of the workshop content, the set of

ICT-related skills reported in [45] served as a reference. The workshops include the majority of the skills mentioned in that work, i.e., the abilities to undertake problem-solving, construct dynamic models of real-world processes, select and recombine media content, and scan information focusing on relevant details, together with the ability to interact meaningfully with tools to enhance mental capacities. Development of the abilities to collect knowledge, share it with others, evaluate the reliability of an information source and disseminate information completes the training goals.

A key aspect of Riconnessioni distinguishing it from the abovementioned initiatives is that teachers become relevant actors in spreading knowledge and lessons learned from attending labs and workshops through so-called *cascade training*, making it easier and faster to reach and train a broad group of colleagues. To this end, a significant portion of the workshops are intended to allow teachers to reflect on how they can transmit their knowledge to their peers. A further advantage of the project is its systemic approach addressing several domains together, such as improving existing infrastructure, training teachers, and involving other relevant stakeholders, such as school administrative and managerial staff.

III. THE "RICONNESSIONI" ("RECONNECTIONS") PROJECT

To support schools in navigating the complexities highlighted in Section 1, helping them improve their educational proposals and curricula, the Compagnia di San Paolo, in agreement with the Ministry of Education, University and Research (MIUR), began the "Riconnessioni" project, created by the Foundation for the School [11]. The three-year project combines the energies of teachers, managers, administrative staff, students, families, policy-makers, publishers, application developers, associations and the entire educating community to experiment with new learning models, share the risks encountered and take advantage of the opportunities that emerge. The Reconnections project builds upon a system model aimed at technological, organizational, and educational innovation in primary and secondary schools, first grade. The project started in 2017 with a multiyear implementation horizon and is being implemented in schools in Turin (Piedmont, Italy) and its inner suburbs. It can be briefly described by identifying two primary forms of action – one infrastructural and the other formative – both oriented to a more significant and broader digital transformation of schools. Fig. 2 depicts the Riconnessioni intervention model, composed of five functional layers assigned to three complementary domains: Infrastructure & Devices, Training Trainers, and Analytics. These layers describe transformation core processes from the Riconnessioni perspective.

Concerning infrastructure & devices (P1 & P2), due to collaboration with experts in the sector, Riconnessioni is bringing fiber-optic Internet connection (P1) into all school complexes and creating or updating internal systems (P2) to access the network. Schools are assisted in analyzing require-

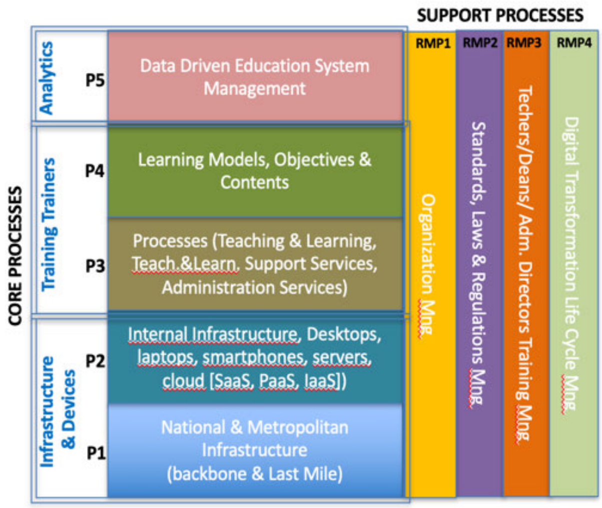

FIGURE 2. Riconnessioni Layered Digital Transformation Intervention Model. Domains: Infrastructure & Devices; Training Trainers; Data Driven Education System Management (work still in progress).

ments and defining the most functional solutions to enforce innovative development, taking advantage of collaboration among school managers, technicians, and teachers.

Regarding *training trainers (P3 & P4)*, which is the heart of the project, the aim is to promote innovative ideas and practices, involving school managers, teachers, students and parents through a continuous training course that can exploit the potential of digital technology. The most crucial component of the training intervention is to be identified in "ad hoc" courses for managers and teachers: the former are more interested in the digital culture to be sustained in the organizational and operational processes of the school, level P3, and the latter, P4, include five different course instances, each focusing on a different theme, that look at the digital scenario as both a resource for teaching and an object of the teaching action itself. A further topic illustrates and puts into practice innovative teaching methods as alternatives to the more classical front approach. Labs involve groups of teachers from each school complex and last one week. Teachers are supported to spread the content they learn among their colleagues at school to enhance the training process, in the first level of cascade training. In addition to the training courses described above, thematic training courses have also been developed, called "Classroom B" labs. They are organized in cooperation with other partners and are mainly for teachers already trained in Classroom A. To complete the picture, a permanent set of workshops, seminars, events, and conferences are also organized, aimed at guiding and promoting a "future-oriented" school.

The third domain (P5) in Fig. 2 concerns *data-driven management* and addresses adaptive education systems; it is still in the implementation phase today.

Vertical bars in Fig. 2 indeed represent Riconnessioni's management processes (RMPs), which include organization, standards, law and regulations, systemic training, and project life cycle management.

Hence, the systemic approach of the project, which is described in the following, is mainly focused on two complementary fronts: infrastructure to guarantee fair access and teacher training to spread digital know-how.

A. INFRASTRUCTURE & DEVICES

The problem of access to the network arises for schools in all its complexity. In Piedmont, only 3% of schools in the first cycle and 18% of those in the second cycle have a fiber-optic connection. For a medium-sized school, it is challenging, if not impossible, to work on a network without such a connection. The UN Human Rights Council's nonbinding resolution A / HRC / 32 / L.20, also signed by Italy, establishes the need to promote Internet access in educational settings and digital literacy in schools. Although the last few years have seen steps in this direction, the existing infrastructure appears insufficient to fulfill the task, aside from particularly successful schools. Here, too, technological development risks increasing the gap between those who can afford access and those who cannot.

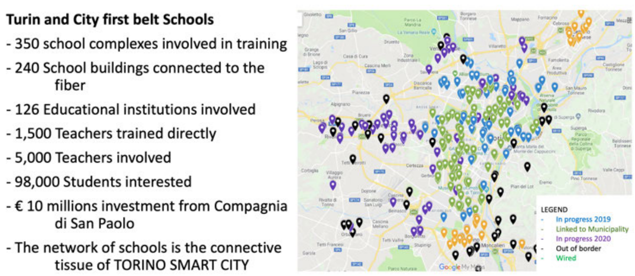

FIGURE 3. The "Riconnessioni" project at a glance.

The general setting of the technological infrastructure of the "Riconnessioni" project envisages a classical stack organization where each level can be implemented with different solutions (Figs. 2, 3). Respecting the constraints that make communication between the different levels successful, the final result is always consistent with that expected by the model. This setting is particularly valuable for the geographical scalability ambitions of the project itself.

1) FIBER-OPTIC & INTERNET ACCESS

In this hierarchical model organized in layers, the fiber-optic metro network is one of the essential components, at the first level of priority. In the city of Turin, a municipal infrastructure dedicated to the schools involved has already been built, entirely based on optical fiber, organized according to a star topology (Fig. 4). Specifically, the 10 gigabytes per second optical fiber is being brought to 300 school sites by 2020 and will impact more than 50% of teachers of primary and secondary schools in Turin and its metropolitan area. This infrastructure underpins an extensive training program on digital skills and innovative learning (Fig. 5).

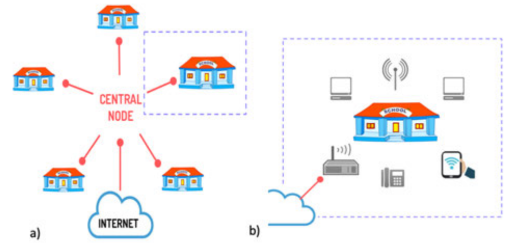

FIGURE 4. a) Metropolitan network; b) School building network.

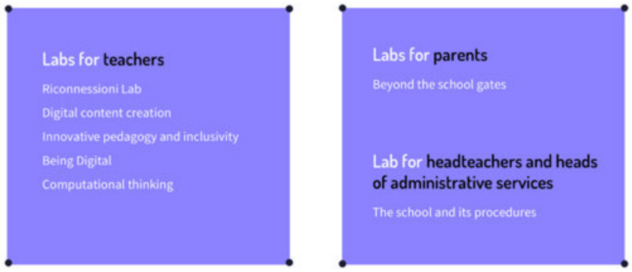

FIGURE 5. The riconnessioni labs.

Regarding Internet access, the schools involved in the "Riconnessioni" project are included in the Italian Network of the University and of Scientific Research, commonly called the "GARR Network", whose services are mainly intended for the community belonging to the Ministry of Education, University and Research (MIUR) [52]. The technical features of the GARR network allow for limited transmission delays: this makes it particularly suitable for not only transmitting large amounts of data but also real-time communication and high-definition audio/video transmission [47].

2) INFRASTRUCTURE FOR INTERNAL CONNECTION IN SCHOOL

In addition to implementing a new fiber-optic network dedicated to schools, Riconnessioni is also improving the internal connection infrastructure of school buildings, equipping schools with reliable, capable and capillary local networks and providing adequate network coverage to carry out all administrative and educational activities effectively. The goal of these steps is to allow schools to free themselves as much as possible from management concerns, instead exploiting a unique infrastructure, virtualized according to the "cloud computing" paradigm, ensuring centralized remote control of resources and managed by an entity outside the schools.

The interconnection of school complexes and the subsequent use of the infrastructure is highlighting the need to develop adequate control and information return activities through the use of specifically dedicated dashboards.

In fact, for all the levels in the model, a permanent active monitoring system has been created, relating to the quality of the service and the state of the equipment. For this purpose, every element of the infrastructure is monitored and alarmed to guarantee complete management and monitoring of the operations to proactively signal any anomalies in the equipment functioning (Fig. 4).

The process of building the network infrastructure is currently underway, and some plexuses still remain to be reached by the fiber.

B. TEACHERS AND SCHOOL STAFF TRAINING

The infrastructure created with Riconnessioni is the starting point for a revolution in education and school management. Digital transformation is not an end in itself but is an enabling factor for broader change in the school, enhancing inclusion and creativity.

Riconnessioni is a sociotechnological systemic project whose purpose has been clear from its vision statement since its beginning:

"We strive for a school to:

1. *Become Laboratories* where communities carry out projects through real-world learning.
2. *Develop Skills* such as practical know-how, digital competences, and collaboration.
3. *Open Their Doors* to people near and close, to welcome and understand diversity.
4. *Include Innovative Technology* such as robotics and virtual reality, enriching teaching rather than hindering it.
5. *Learn How To Change Themselves* as continually evolving systems in which all parts are interconnected.
6. *Continuously Train Their Staff* through pathways designed to innovate teaching and learning.
7. *Support Their Leaders* in implementing technology designed to boost creativity and entrepreneurial school management.
8. *Change Together* with teachers, head-teachers, students, parents: education is a cooperative project."

With this perspective, the training labs [11] provided through the "Riconnessioni" project are focused on the identification and creative development of pedagogical, educational [10], technological and organizational solutions, oriented toward the overall improvement of schools. This transformation emerges from the base, the teachers, through participatory and constructive identification of the means and ends necessary to promote shared systemic change.

The analysis of national and international good practices and dialogue with national and international partners, supported by a pattern of consultation of the educating community, has led to the establishment of five lab training programs for teachers [53]. These programs are characterized by the prevalence of experimental activities and the exchange of good individual practices among the teachers themselves. The training activities planned by Riconnessioni will take place on a large scale as they aim to involve at least 60% of the teaching staff of primary and secondary schools' first cycle in Turin and its metropolitan area (Fig. 3).

Working with technology, seen as a means, not an end, has led to the identification of five themes, reported in Fig. 6, which shape five lab paths. As of November 2019, Riconnessioni has already involved nearly 550 teachers:

- *Riconnessioni lab* - promoting a culture of self-assessment and focus on digital skills [53], [54];
- *Computational Thinking* - enhancing logical reasoning, problem-solving and an introduction to programming and robotics [55]–[58];
- *Creating Digital Content* - an introduction to tools for creating digital content at no cost and experimenting with analog-digital hybrid approaches to enhance creativity [59], [60];

DIGCOMP 2.1	LABS					
	RIC	CT	DCC	ITI	BD	SP
INFORMATION & DATA LITERACY						
Browsing, searching and filtering data, information and digital content	X		X			
Evaluating data, information and digital content			X		X	
Managing data, information and digital content		X	X		X	X
COMMUNICATION & COLLABORATION						
Interacting through digital technologies	X	X	X	X		X
Sharing through digital technologies		X	X	X		X
Engaging in citizenship through digital technologies				X	X	X
Collaborating through digital technologies	X	X	X	X		X
Netiquette					X	
Managing digital identity					X	X
DIGITAL CONTENT CREATION						
Developing digital content	X		X	X		
Integrating and re-elaborating digital content			X	X		
Copyright and licences			X		X	
Programming		X	X			
SECURITY						
Protecting devices						X
Protecting personal data and privacy				X	X	X
Protecting health and well-being				X	X	X
Protecting the environment						X
PROBLEM SOLVING						
Solving technical problems		X				X
Identifying needs and technological responses	X			X	X	X
Creatively using digital technologies	X	X	X	X		X
Identifying digital competence gaps	X			X		X
Legend						
Lab identifiers: RIC: Riconnessioni; CT: Computational Thinking; DCC: Digital Content Creation; BD: Being Digital; Innovative Teaching & Inclusion; SP: School Processes						

FIGURE 6. DIGCOMP 2.1 vs riconnessioni's LABS.

- *Being Digital* - overcoming digital prohibitionist perspectives in favor of conscious use of tools [61], [62] for one's own virtual identity and privacy;
- *Innovative Teaching and Inclusion* - exploring the inclusive potential of new technologies in working with heterogeneous class groups and networking of schools and associations [63]–[66].

In addition to the labs for teachers, an additional one has been created for school managers and administrative staff:

- *School Processes* - an overview of the Riconnessioni project, including approaches to fostering innovation and promoting collaboration among schools.

Fig. 6 presents the rationale for the competence profiles, rooted in a recognized European reference standard, the DigComp framework [67]. This framework was chosen for its suitability to the digital transformation context addressed in Riconnessioni, which requires a broad skill spectrum to sustain the increasing complexity of the education ecosystem.

In the following, detailed information on the objectives, duration, and structure of each lab are provided (additional information on each workshop is provided in Appendix A [68]). It is worth mentioning that, as is apparent from the labs' structure, each lab for teachers has a strong focus on good-practice frameworks to enable subsequent transfers of competences to other colleagues (*cascade training*).

1) RICONNESSIONI LAB

This training program aims at promoting self-assessment of digital skills. It is organized over three training days (twenty-four hours) addressing teachers. The training plan is as follows:

- *Day 1*: the objective is to provide teachers with knowledge of DigComp for citizens, DigCompEdu, and DigCompOrg frameworks to educate them about instruments for assessing digital skills and help them identify improvement techniques.
- *Day 2*: here, the objective is to foster teachers' interest in developing innovative training, taking advantage of learning environments, reflecting on the trainer's role, providing an overview of tools and methods for innovative/digital training and letting teachers gain experience in practical applications of such tools.
- *Day 3*: the activities aim at encouraging the sharing of individual training experiences and collaboration among teachers. At the end, teachers are also asked to reflect on the topics learned in the previous training sessions and discuss how the competencies and skills they have acquired can be transmitted to their colleagues.

2) COMPUTATIONAL THINKING

This training program aims at providing an overview of methods and tools to enforce skills and competences on computational thinking and coding. In particular, it covers methods for teaching problem posing, solving, and coding. The training program also entails experimenting with tools for teaching robotics to acquire Scratch and mBlock programming skills. It is organized into four training days (thirty-two hours) for teachers. The course plan is as follows:

- *Day 1*: the main objective is acquiring some basic programming concepts related to the Scratch development environment, as well as the use of creativity to solve some simple programming problems. Teachers also experiment with learned techniques, adapting them to their specific training courses. A unique activity performed during this day is so-called "Reverse Mentoring", when teachers become the learners and are supervised by primary and secondary school students.
- *Day 2*: teachers use creativity to apply some simple problem-posing and -solving techniques. They also acquire further skills on educational robot coding and learn how to use the Scratch framework to develop simple programs.
- *Day 3*: teachers fine-tune skills related to robot coding, applying the Scratch framework to group work.
- *Day 4*: teachers design training units by using knowledge acquired during lab sessions and create dissemination plans for their schools.

3) CREATING DIGITAL CONTENT

The objective of this course is to provide teachers with a set of tools, resources, and methods so that they can become authors of digital content and create new advanced educational material. It is organized over three training days for teachers only. The training process is structured as follows:

- *Day 1*: teachers understand and grasp the potential of digital training resources, can define the value of digital content, reflect on the evolutionary process from paper to digital content, are familiar with Creative Commons licenses and intellectual property, can adopt strategies for searching and using online material, and know how to validate a source.
- *Day 2*: teachers learn guidelines, methods, and tools for creating digital content, referring to apps and videos run during classes to support learning.
- *Day 3*: teachers are provided with guidelines, methods, and tools to create and develop digital products in class (e.g., Stop Motion videos) that can support learning. The course also addresses the development of skills to transmit acquired knowledge to colleagues.

4) BEING DIGITAL

This training process aims at helping participants understand the digital revolution and its influence on education in terms of teacher work and student learning. The course also demonstrates tools that can help teachers embrace digital change and exploit its potential with critical thinking. The lab first asks teachers to reflect on the relationship between society and technological developments, specifically by studying the history of information technology and drawing out some lessons to understand the impact of digital processes. Then, the training provides teachers with some basics on computers and the Internet. Finally, it creates a map to help trainers orient themselves in the digital world, understanding its opportunities and risks and future trends it may create. The lab is organized into three training days, for teachers only. Its structure is as follows:

- *Day 1*: its objective is to study relations between society and technological development by providing teachers with an overview of the history of communication technology.

- *Day 2*: it is devoted to helping teachers understand the historical and cultural context in which computers and the Internet were born and evolved to better handle today's digital revolution.
- *Day 3*: this day addresses teachers' questions, gathered on the previous days, and provides an introduction to free software and open educational resources.

5) INNOVATIVE TEACHING AND INCLUSION

This lab aims at building skills and competences in customizing teaching to foster cultural/linguistic inclusion, also satisfying special education needs, by providing an overview of existing methods and tools. In particular, teaching activities are focused on two aspects: intellectual difficulties (i.e., special education needs and specific learning disabilities) and cultural inclusion (i.e., migrants). It is organized over four training days (thirty-two hours) for teachers only. The course structure is as follows:

- *Day 1*: the objective is to improve experience-sharing among teachers, introducing digital technologies able to support inclusive teaching, particularly addressing students with special education needs and specific learning disabilities.
- *Day 2*: it provides teachers with tools and methods to foster cultural and linguistic inclusion.
- *Day 3*: teachers learn to work with local associations to build long-lasting networks. They also perform collaborative design working with other teachers and association staff.
- *Day 4*: the objective on this last day is to provide teachers with tools to transmit acquired competencies and skills.

6) SCHOOL PROCESSES

This lab is aimed at school managers and directors of general and administrative services of the schools involved in the Reconnections project. The objective is to guide them toward using and implementing digital tools to innovate the processes, planning, and strengthening of school entrepreneurship. At the same time, it aims to lay the foundations for the construction of school networks.

- *Day 1*: the aim is the innovation of school processes from the perspective of the school organization. It covers laws and regulations focused on school assessment development in line with public policy. Riconnessioni project monitoring and assessment are also considered from the perspective of the planned surveys.
- *Day 2:* topics on this day are laws and regulations on the use and protection of data. General perspectives on the document management system, public procurement, and the Public Contract Code are also introduced.

More details on labs organization are also given in [68].

IV. MONITORING & ASSESSMENT

The monitoring and evaluation activity has the objective of collecting, throughout the entire period of project development, information on the progress of the various actions and the results achieved. These objectives can be summarized as follows:

- from the perspective of implementation, verify the consistency of accomplishments concerning what was planned, identifying any critical issue arising in the development processes;
- from a reporting standpoint, regularly describe what is attained within the project;
- from the outcome perspective, identify and measure the changes the project is producing, especially in terms of behaviors at the level of school function management and skill improvement shown by teachers and students.

An alternative schema for the same objectives can be proposed according to the categories of interventions carried out and the actions those categories comprise:

- *infrastructural intervention*: the analysis looks at this aspect as a priority from the standpoint of reporting, in relation to what is achieved, by whom and with what timing. In terms of implementation analysis, the investigation focuses on any obstacles and/or critical issues regarding the realization of the planned tasks; in terms of evaluation of the effects, the question is to what extent the infrastructural intervention produces visible changes for the beneficiaries;
- *training*: regarding reporting, it documents the regular execution of the planned training courses; concerning implementation, the focus is on both the quality and the usefulness perceived by the participants and the behaviors adopted after participation in the courses; regarding effects, it evaluates changes in the behaviors and competences of the subjects involved attributable to what was transmitted, directly and indirectly, by the labs.
- *other communication and dissemination actions*: these are primarily objects of descriptive activity attributable to the reporting of the achievements.

Fig. 7 shows the "*logical model*" of the project. It illustrates an idea of the consequentiality of the main actions (from 1 to 5), their development, and their expected results, with a relationship between any two single aspects arising from infrastructural and training actions and the analytical logic to which observation of this relationship is primarily ascribed. This representation is a way to describe, through a diagram, the different hypotheses that make up a specific theory of change, and it is functional to the definition, in agreement with the actuators, of the questions to be addressed in the analysis phase. The representation of the model is necessarily schematic in some of its perspectives because part of the planned investigation lies on the border between different stated logics. Hence, the process includes the following four milestones:

a) Periodic surveys on primary data on achievements based on a staff questionnaire;
b) Survey of participants in the labs based on a feedback questionnaire;
c) Survey of participants' behavior after lab attendance based on a follow-up questionnaire;
d) Survey assessing the effects.

Below, detailed descriptions of the milestones are provided.

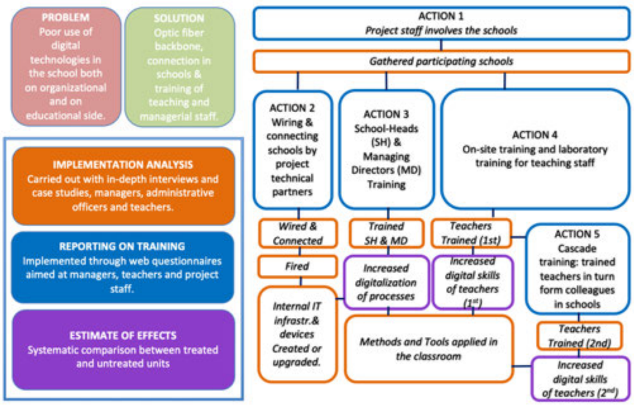

FIGURE 7. **Riconnessioni logic model & assessment framework.**

A. PERIODIC SURVEYS ON ACHIEVEMENTS

a) provides a synthetic framework to describe the main actions undertaken. Relevant questions are the following: "*At what point is the infrastructure progressing? How many school complexes are linked to the metropolitan backbone? How many schools have been connected? How many lab training cycles have been carried out so far? How many people are involved? What types of schools? How many communication and presentation initiatives have been implemented?*". These are only some of the questions framing the general operation of the project and its state of progress.

The data that feed this descriptive system, whose content is defined with the project staff, are provided monthly through a web questionnaire compiled by the same staff. Riconnessioni collects both information owned directly by the staff and information that the staff gathers from other actuator partners (TOP-IX and Open-fiber).

The role of periodic reporting is essentially accounting. The resulting measures combine to form – with an appropriate selection of data from the follow-up surveys – the KPI framework, an overall summary of achievements and successes within the project framework.

B. SURVEY OF PARTICIPANTS - FEEDBACK

In b), teachers and managers who attended the labs are asked to complete a feedback questionnaire (FB) at the end of their work. This questionnaire, assigned on the last workshop day, must be completed online through a dedicated platform and is used to collect opinions on:

- the course organization;
- the quality of the various learning modules;
- the levels of novelty and user-friendliness of the covered topics;
- any additional needs for the participants to be able to implement what they have learned.

The role of the feedback surveys is mainly that of implementation analysis; they are useful on one hand to progressively construct a final judgment on the perceived quality of the labs and on the other hand to provide immediate information on any needed review before the transition from one training cycle to the next.

C. SURVEY OF PARTICIPANTS - FOLLOW-UP

Regarding c), teachers and managers who have participated in the workshops are asked to complete a follow-up questionnaire (FU) at a particular time distance from their course attendance. Like the FB, the FU requires the completion of an online questionnaire made available on the platform. The teachers take the FU at two different specific time distances from the lab they attended: first after three months and second after twelve. In contrast, the managers complete only a single questionnaire at a fixed time.

While the FB, described above, is used to obtain immediate information on participants' perceptions of the labs, the FU is useful to learn of the potential uses attendees envision making of what they have learned. From managers, the survey elicits information on the use and friendliness of digital tools for school management in general terms, such as:

- recent changes in the institutional training offering plan taking advantage of a more extensive spread of digitization;
- use of applications for organizational and teaching management and also to develop relationships with students and families;
- provision of general IT facilities in the schools.

With teachers, the survey focuses on the use and friendliness of specific digital tools and topics, learned for teaching and pedagogy management, in particular:

- the beginning of cascade training with colleagues and how it has been organized and managed;
- use in the classroom with students and how teaching has been planned and executed;
- use of technical specifications and specific application software covered in the labs;
- the actual availability of digital infrastructures;
- constraints and obstacles encountered, needs that have emerged, and reactions of colleagues.

The role of the FU is mainly that of project progress analysis from the training perspective: in fact, they help verify the accuracy of some primary hypotheses. In particular, the focus on teachers makes it possible to highlight a component that is considered fundamental: if a direct action of Riconnessioni in terms of teacher training is essential, the cascade training that the trained teachers themselves perform for other colleagues is even more critical.

On the managerial side, the need to investigate implementation is combined with the need to grasp certain changes at the organizational/management level of which school managers are privileged witnesses. In this case, expectations of significant structural changes are less intense than the expected growth for teachers, but the objective remains to verify, on one hand, the existence of certain organizational foundations in schools, and, on the other hand, detect the spread of change.

If the FU can serve to capture the current state of affairs, the comparison between changes occurring in schools of trained and untrained managers can gauge the effects of the Reconnections project, as illustrated in the following section.

D. SURVEY ON EFFECTS

In d) effects assessment seeks to verify, in a causal sense, whether the operations carried out by Riconnessioni are producing change in the entire context. In other words, it investigates whether the condition of the schools would have differed in the absence of Riconnessioni. Two questions posed by the Foundation motivate this analysis:

1) *Can we determine whether the introduction of digital tools and culture at the management and organizational levels, together with their role in planning school activities, cause change due to the interventions promoted by Riconnessioni?*
2) *Can we determine whether the skills of teachers and students change due to the specific actions promoted by Riconnessioni?*

By using the terminology of the counterfactual assessment, the objective is to verify whether a specific "treatment" has produced a change in a particular "result variable", such as measurement of a phenomenon that may be affected by Riconnessioni operations. Teachers' and students' skills can be relevant result variables, even if students' skills are only indirectly affected by Riconnessioni. The main components of the project have been taken into account to define the "*treatment*" of interest:

- *infrastructural operations*, which should facilitate use of the network by providing a faster, more widespread and more accessible connection; in this case, the "*treatment*" can be defined as connecting the school complex to the optical-fiber-based city backbone;
- *training actions*, which should provide a stimulus to change, use, and disseminate learned content, and the "*treatments*" in this case can be further defined as follows:
  - *from the managerial standpoint*, participation in dedicated labs, such as "school processes";
  - *from the teachers' point of view*, participation in specific labs and involvement in subsequent cascade training.

The "result variables" are instead measurable quantities, built ad hoc, to adequately describe the phenomena on which the effect is to be evaluated:

a) in the case of school organization and management, the presence/adoption of "digital" structures/tools is considered;
b) in the case of teachers' and students' competences, a measurement criterion is defined for two types of skills:
   - *the digital competencies that Riconnessioni advocates;*
   - *the noncognitive competencies attributable to them.*

Concerning a), observation of the "digitalization" level of school processes is carried out with managers and other school leaders. As noted above, the "follow-up" survey regularly examines all the managers, both trained and not trained, who are asked to provide information on a series of organizational and infrastructural conditions linked to the digitization of each school complex. The first-year survey contains a series of thoughtful questions to reconstruct not only the current situation but also the past one through the managers' statements. The survey is carried out via a questionnaire delivered online on a dedicated platform.

Regarding b), the digital and noncognitive skills of teachers and students are measured by an ad hoc test, named the Riconnessioni test (Rt), carried out as part of the project itself. This test, which consists of approximately 30 questions, is divided into two distinct parts, one, with greater weight, dedicated to digital skills and the other to noncognitive skills.

Each domain of interest (teachers, primary school students, lower secondary school students) has a specific test, built around different processes. In any case, the starting point is discussion with the project staff and project trainers involved in the labs, who provide useful information to focus on priority issues and develop homogeneous sets of test questions.

In the case of digital competences, review of the existing theory on the topic and comparison by the project staff led to identifying the European DiGComp framework [67] as a reference point to develop the questionnaires. With this framework in mind, the Citizens version for students and the Edu version for teachers are assumed as bases, establishing a bottom-up logic for the questionnaire development process.

So far, the potential "treatment variables", a target of the assessment process, have been defined, also showing where the "result variables" can be sought. The method of effects estimation is briefly described below.

For this purpose, reference is made to a specific treatment variable T, which is True if it means "treated" and False otherwise and to a specific associated "result variable" Y:

- T traces a group of teachers in the school complex who participated in the workshops;
- Y represents the digital skill levels of the students of the same plexus, measured by an ad hoc test.

The assessment question in this case is: "*Did the teachers' group lab attendance increase the digital skills of the students in their classrooms?*". This question entails comparing the skill levels of the plexus students with the levels observed previously in a different "control group" in the absence of a lab. Since the second term is not known, the effect cannot be measured but instead only estimated, involving nontrivial problems:

- if the estimate is obtained by comparing levels between treated and untreated plexuses, it is distorted by the selection because there is a very high risk of wrongly ascribing to the treatment a difference in levels that already existed before the labs;
- if the appraisal is obtained by comparing the pre- and post-treatment levels of only the treated plexuses, there is the risk of wrongly ascribing a difference to the treatment when any variation might be simple and spontaneous; that is, the estimate might be distorted by implicit uncontrolled dynamics.

1) DIFFERENTIAL EFFECTS OF A TREATMENT

The Difference in Differences (DiD) statistical technique has been chosen to reduce the risk of overexposed distortions in the analysis.

The idea is to exploit the fact that treatments take place for different plexuses in different conditions and times, as specified in the following:

- the first observation of Y is conducted on two groups of plexuses at time T1 before treatment is performed;
- the second observation of Y is performed later, at T2, after a group of plexuses has been treated.

The observation of any differences at T1 suggests the existence of structural differences. Hence, assuming that these remain unchanged at T2, in the absence of training, relevant differences detected should be ascribed to the treatments applied between the two observations.

The logic of the DiD method is shown in Fig. 8, in which the average levels of the two groups "before" and "after" treatment are compared to estimate the change produced by the training. This framework can be generalized to all the treatments and all the expected result variables, including the joint occurrence of different forms of treatment.

From an operational standpoint, the analysis plan includes:

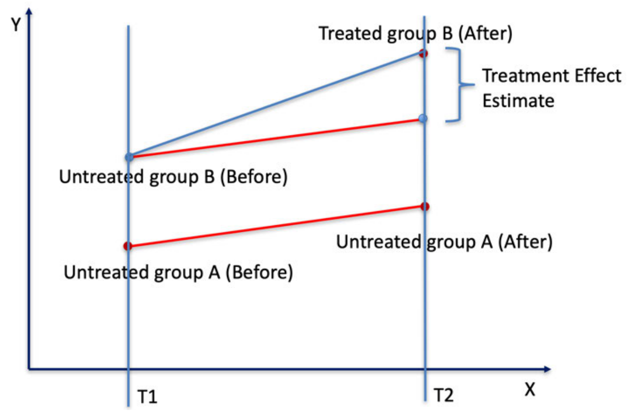

FIGURE 8. Difference in differences (DiD).

- in terms of organization and school management, all the school complexes in Torino and its inner suburbs;
- concerning teachers' skills, all the teachers related to the complexes, as noted above;
- regarding student competences, all the students of those complexes who attend, in each year of observation, the fifth classes of the primary schools and the third classes of the lower secondary schools;
- concerning the first survey on the result variable Y, it has been done between October 2019 and January 2020, and the second is scheduled for January 2021 (results of the survey will be published on project's website [11]).

According to the analysis plan, at the first survey of Y, some plexuses may have already been involved in one or more treatments. Should any plexus not have received all the possible treatments, it can always function as a "control" unit for the treatments from which it has been excluded. The coexistence of treated and untreated units covered in the first survey also provides a way to shape, in the first year - albeit from a purely descriptive viewpoint - a summary of the differences that can be observed among all the groups considered.

V. RESULTS

The training activities proposed to the teachers are organized in separate cycles, with the aim, where possible, of activating various learning paths to follow the infrastructural dynamic in progress in connectivity.

Several lab cycles have been scheduled, carried out annually. In November 2018, three training cycles were completed. The results are shown in Table III and indicate that 580 teachers completed the training process, of which 75 attended the Riconnessioni lab, 162 the Creation of digital content lab, 122 the Innovative Teaching and Computational Thinking lab, and 93 the Being Digital initiative.

Three survey sessions were held collecting feedback in February, June, and November 2018. The results evaluated after the interviews are discussed in the following paragraph (detailed results are reported in Appendix B [68]).

Notably, cascade training is extremely important in a systemic framework due to its scalable growth and, particularly, the relevance of the activities planned and carried out by the teachers themselves in their peers' classrooms after they have been trained in the Riconnessioni labs.

Hence, after the feedback obtained at the end of the courses, a follow-up process was established to examine teachers' behavior and the results they achieved in organizing subsequent cascade training in their schools. The survey was conducted through web-based investigation, and participants first responded three months after the end of their lab attendance, with the same process conducted again after twelve months; the last data were collected in November 2019.

The performance analysis developed for the teachers also shows the positive impact of some teaching methods used in

TABLE 3. Feedback: number of attendees and response rates per session recorded in the labs (Q1)

Lab	Num. of Respondents/Attendees			TOT		% Respondents		
Q1	S I	S II	S III	Tot	%	S I	S II	S III
Riconnessioni	23	12	23	58	13%	20%	10%	12%
Creation of digital contents	30	31	61	122	28%	26%	25%	32%
Innovative teaching	17	33	40	89	21%	15%	26%	21%
Computational thinking	22	29	38	89	21%	19%	23%	20%
Being digital	22	20	28	70	16%	19%	16%	15%
Total Respondents	114	125	190	429	100%	100%	100%	100%
Given Attendees & Feedback Response rate	212	160	209	581	74%	54%	78%	91%

the labs, such as "Reverse Mentoring", adopted mainly in the Computational Thinking lab.

To identify effects, a specific survey has been be carried out between October 2019 and January 2020 and a second one will be carried out in January 2021 to complete the assessment stages foreseen by the plan described in section IV.

A. FEEDBACKS SURVEY

The first survey session, held in February 2018, noted the preferences expressed by the teachers who attended the *Riconnessioni lab* in the first cycle. They were asked to complete a standardized web questionnaire with closed-ended questions. Table III shows that there were 114 respondents of a total of 212 participants, with a response rate of 54%.

Of these, 53% came from lower secondary schools. The subjects taught by the participants were mainly sciences (50 teachers), followed by those typically associated with the Italian language and literature (47). The lab most attended was *Digital Content Creation* (26%); the one least attended was *Innovative Teaching* (15%).

In the second session, held in September 2018, there were 125 respondents of 160 participants, as reported in Table III, with a response rate of nearly 80%, much higher than the 54% rate in the first cycle. In this case, three of five teachers came from primary schools (68.6%). The subjects taught by the respondents were mainly in the scientific domain (54%), followed by those typically associated with the Italian language context (43%). The most attended lab was *Innovative Teaching* (26%), while the least attended was the *Riconnessioni lab* (10%).

An analysis conducted in November 2018 examined teachers' perceptions and achievements when attending the third cycle of the Riconnessioni labs. Table III shows there were 190 respondents of 209 participants, with a response rate of over 90%. Almost three of four teachers came from primary schools (78%). The subjects taught by the respondents were mainly in the sciences (50%), followed by those typically associated with the Italian language domain (48%). Here, the respondents had more or less the same composition as the previous cohorts. Among the respondents, the preferred lab choice was *Creating digital content* (32%), while the least chosen was *Riconnessioni* (12%).

In Table IV, the entire set of questions composing the questionnaire is reported to show direct relationships with the corresponding answers. Detailed results are reported in Appendix B.

1) RELEVANT FINDINGS

The primary objective of this feedbacks survey is to collect "hot" opinions on lab quality and usability of concepts learned on site. The response rate increased up to 91% garnered in the 3rd session, compared with 54% in the first and 80% in the second (Table III). The level of declared satisfaction was consistent in all the surveys. Below results from the first three cycles of labs (reported in detail in the Appendix B) are summarised:

- Learning objectives of the labs: respondents express broad consensus (95%) for objectives achievement. Most (four out of five respondents) did not know the covered topics. Among those who knew about it, just a half (20% of the total) already used them previously in class.
- Reviews on lectures: all the labs show high levels of satisfaction for the mastery of the topics shown by the teachers; in fact, 81% declare to be very satisfied. Positive, to a lesser extent, the perception of the ability of teachers to communicate contents, while used material and tools are considered mostly adequate (93% satisfied).
- Workshop reviews: respondents express deep satisfaction both for their involvement in activities carried out on-site using discussion and comparison (93% of positive reviews). Overall, what they learned at labs is perceived (90%) as transferable to student classrooms. 73% believe that what learned on subjects is interdisciplinary

TABLE 4. Feedback - interview questions

Labs		**Workshops**	
Q1	Which laboratories did you take part in? *(Riconnessioni, Creation of Digital Content, Innovative Teaching, Computational Thinking, Being Digital)*	**Q9**	Does the teacher know how to involve the participants? *(Substantially, Somewhat, A Little, Not at all)*
Q2	Have the objectives of the laboratory been achieved? *(Substantially, Somewhat, A Little, Not at all)*	**Q10**	Can the teacher stimulate dialog, discussion, and comparison? *(Substantially, Somewhat, A Little, Not at all)*
Q3	The content presented was: *(Totally new, Fairly new, I knew but did not apply it, I knew and applied it already)*	**Q11**	Are the teaching method and tools useful for the work to be done in the classroom? *(Substantially, Somewhat, A Little, Not at all)*
Q4	What would you most need? (users can indicate more than one answer: *More training, More material, More technology, Other*)	**Q12**	The teaching method and tools will be applicable*: (For more disciplines, but only for segments of curricula, Only for specific disciplines, Transversely to disciplines and topics)*
Q5	To address the themes, different teaching methods were used (express a judgment on the adequacy of the time dedicated to them; *Excessive, Adequate, Poor*).		
Introductory lessons		**Riconnessioni staff**	
Q6	Has the teacher mastered the contents? *(Substantially, Somewhat, A Little, Not at all)*	**Q13**	Does the staff know how to involve the participants? *(Substantially, Somewhat, A Little, Not at all)*
Q7	Does the teacher clearly communicate the concepts? *(Substantially, Somewhat, A Little, Not at all)*	**Q14**	Does the staff know how to stimulate the comparison? *(Substantially, Somewhat, A Little, Not at all)*
Q8	Are the materials adequate? *(Substantially, Somewhat, A Little, Not at all)*	**Q15**	Are the teaching method and tools useful for the work to be done in the classroom? *(Substantially, Somewhat, A Little, Not at all)*
		Q16	Are the tools adequate to handle dissemination to colleagues? *(Substantially, Somewhat, A Little, Not at all)*

and applicable both on the discipline and on any single topic.

- Reviews on Riconnessioni staff: positive and concurring appraisal regarding the ability to involve (80%) and stimulate discussion (81%). Overall, the work processed by the staff is considered adequate (92%) to the requirements emerging when dealing with dissemination and cascade training, to be put in place subsequently by the attendees.

B. FOLLOW-UP SURVEYS

The main objective of the follow-up investigations is the identification of the degree of activation of the teachers when they return to school after attending the reconnection labs. The study mainly concerns cascade training carried out with colleagues and classroom application with students of what they have learned.

Below, a summary of the results of the first, second, and third follow-up surveys are reported. The surveys were carried out of the trained teachers three months after their attendance of the corresponding Riconnessioni lab cycles, held in July 2018 and January and February 2019. The main objective is to learn about their skills, actions, and experiences, knowing their school levels and disciplines (i.e., primary, secondary first cycle, mathematics, languages). The same test has then been repeated twelve months after the end of each lab cycle, carried out in February, July, and November 2019 to obtain a follow-up picture of the entire domain comparable with that drawn three months after the labs' end.

Table V shows the questions the respondents addressed, organized in four different survey areas:

- Area I - labs and participants, to represent teacher distribution over the five labs, for disciplines and school levels;
- Area II – subsequent cascade training to monitor the spread of training actions disseminated by teachers trained in the Riconnessioni labs, with fourteen questions addressing already-begun cascade training actions, attendance figures, and tools and methods applied in the classroom;
- Area III – application of learning frameworks for students to generate anticipation of effects estimation concerning the impact of learning on students in the classroom;
- Area IV – Riconnessioni follow-up actions after labs: to evaluate activities put in place by the staff with the attendees, together with the interactions among them.

Survey areas II, III, and IV act as a preliminary sample of the estimation that has been carried out between October 2019 and January 2020, together with a systematic assessment process, rooted in DiD principles, as framed in a previous section.

Table VI shows response rates per session sampled at both three months and twelve months after labs attendance. Detailed results are reported in Appendix B.

1) RELEVANT FINDINGS

In the first survey session, 83 individuals completed the follow-up questionnaire (41%) of 202 lab attendees. The respondents were distributed among labs and among primary schools, which accounted for 41 attendees, and secondary schools, accounting for the remaining 42.

In the first cycle of the Riconnessioni labs, 84 attendees completed the 12-month follow-up questionnaire (42%). The

TABLE 5. Follow-up - interview questions

Table Area I						
Labs & Participants		**Answers**				
Ques.	**Title**	**a**	**b**	**c**	**d**	**e**
Q1	Distribution of members by type of lab attended	Riconnessioni	Computational Thinking	Creation of Digital Content	Innovative Teaching	Being Digital
Q2	Distribution of respondents by type of lab attended	Riconnessioni	Computational Thinking	Creation of Digital Content	Innovative Teaching	Being Digital
Q3	Distribution according to the discipline of primary school teachers	Linguistic-artistic-expressive area	Mathematical-scientific area	Historical-geographical area		
Q4	Distribution according to the discipline of secondary school teachers	Mother language, history and geography	Mathematics and science	Art, music, languages, etc.		
Table Area II						
Subsequent Cascade Training		**Answers**				
Ques.	**Title**	**a**	**b**	**c**	**d**	**e**
Q5	Have you already started cascade training with colleagues at school?	No	Yes, and course is complete	Yes, but course not finished		
Q6	What were the main channels to recruit colleagues for the training?	Recruited by the Dean	I recruited them personally			
Q7	With which mode?	Informally	Circular Note	Faculty Board	Email	Written Notice
Q8	Planning of training with colleagues was the subject of a lab session: was it enough for carrying out the course to train your colleagues?	No	Yes			
Q9	These hours of work served you mainly for:	A deepening of what was done at the labs	A partial adjustment of what was done at the labs	A radical adjustment of what was done at the labs		
Q10	Have you ever designed a syllabus in the area of training, working with your colleagues?	No	Yes, with colleagues	Yes, alone		
Q11	Have you had any difficulties working as a trainer for your colleagues?	No, none	Yes, I was uncomfortable because of my inadequate background	Yes, I was uncomfortable because I wasn't prepared on the course topics	Low participation of colleagues	Lack of materials
Q12	Was Internet access available at school during the training with your colleagues?	No	Yes			
Q13	It was available everywhere in the school	No	Yes			
Q14	It was present continuously	No	Yes			
Q15	High speed was available	No	Yes			
Q16	Were the following tools available at the learning site?	IWB	PC	Projector	Tablet	
Q17	To train your colleagues, did you use the following tools? (for management and resource sharing - Padlet, Google Drive, Edmodo, Notability)	Often	Sometimes	Rarely	Never	
Q18	To train your colleagues, did you use the following tools? (for multimedia content creation - Explain Everything, PubCoder, Aurasma, Spre ..)	Often	Sometimes	Rarely	Never	
Q19	To train your colleagues, did you use the following tools? (for assessment - Kahoot!)	Often	Sometimes	Rarely	Never	
Q20	To train your colleagues, did you use the following tools? (for programming - Scratch, mBlock)	Often	Sometimes	Rarely	Never	
Q21	To train your colleagues, did you use one or more of the following experiential teaching methods learned in the labs?	Cooperative learning	Circle of learning	Flipped classroom	Mini hackaton	Reverse mentoring
Table Area III						
Applying in School What Was Learned in the Labs		**Answers**				

TABLE 5. ***(Continued.)*** **Follow-up - interview questions**

Ques.	Title	a	b	c	d	e
Q22	Did you use what you learned in the labs for classroom work with students?	Often	Sometimes	Rarely	Never	
Q23	In which situations did you use them?	For various disciplines	For multiple topics within a single discipline	To convey transversal skills	For activities to be performed at home	
Q24	Why did you not use them?	Students were not receptive	Internet unavailability	Not feeling ready	Inadequate background	
Q25	The planning of student training was the subject of a lab session: was it enough, without requiring any further work on your side, for carrying out classroom lessons?	No	Yes			
Q26	These hours of work served you mainly for:	A partial adjustment of what was done during the labs	A deepening of what was done during the labs	A radical adjustment of what was done during the labs		
Q27	Did you use experiential teaching methods (e.g., reverse mentoring, cooperative learning ...)?	Often	Sometimes	Rarely	Never	
Q28	In which situations?	For various disciplines	For multiple topics within a single discipline	To convey transversal skills	For activities to be performed at home	
Q29	Why did you not use them?	Students were not receptive	Internet unavailability	Not feeling ready	Inadequate background	
Q30	Was Internet access available in your school during classroom activities?	Yes	No			
Q31	It was available everywhere in the school	Yes	No			
Q32	It was present continuously	Yes	No			
Q33	High speed was available	Yes	No			
Q34	Are these devices available in your school?	IWB	PC	Projector	Tablet	
Q35	During classroom activities have you been using the following tools? (for the management and sharing of resources - Padlet, Google Drive, Edmodo, Notability)	Often	Sometimes	Rarely	Never	
Q36	During classroom activities have you been using the following tools? (for the creation of multimedia content - Explain Everything, PubCoder, Aurasma, Spre ..)	Often	Sometimes	Rarely	Never	
Q37	During classroom activities have you been using the following tools? for programming - Scratch, mBlock)	Often	Sometimes	Rarely	Never	
Q38	During classroom activities have you been using the following tools? (for assessment Kahoot!)	Often	Sometimes	Rarely	Never	
Q39	How would you rate the involvement of students with the activities in which you used	Enthusiastic	Active	Moderate	Passive	
	digital content?					
Q40	Do you feel that participation in Reconnections has changed the way you teach?	Yes, in a radical way, for both the content and the teaching method	Yes, at least as far as teaching methods are concerned	Yes, at least for the contents	No, for neither the contents nor the teaching method	
Q41	After courses and workshops, have you changed learning assessment methods for your students?	Yes	No			
Table Area IV						
Follow-up Actions after Labs		**Answers**				
Ques.	**Title**	**a**	**b**	**c**	**d**	**e**
Q42	How would you rate the accompanying work carried out by the Reconnections staff after the end of the labs?	Excellent	Adequate	Acceptable	Insufficient	
Q43	How would you define the relationship that has been established among the lab participants?	Of community	Group	Collaborative	Depends on circumstances	

TABLE 6. Follow-up: response rates per session (Q1-Q2)

Lab	Follow-up 3M Respondents			Follow-up 12M Respondents		
Q1/Q2	S I	S II	S III	S I	SII	SIII
Riconnessioni	32%	20%	21%	33%	26%	23%
Creation of digital contents	13%	15%	34%	19%	24%	31%
Innovative teaching	19%	19%	24%	21%	23%	24%
Computational thinking	19%	24%	24%	20%	24%	28%
Being digital	17%	22%	19%	21%	23%	22%
N. Total Respondents	83	87	132	84	96	116
N. Labs Registrations	211	160	209			

respondents were divided almost equally between primary (52%) and secondary schools (48%).

Summarizing the findings according to the main survey perspectives, the following two domains emerge from the three-month study:

- *Cascade training*: three months after the end of the labs, 57% (Q5) of teachers had begun cascade training; delays were due to the time required to recruit colleagues or to organizational problems within schools. Cascade training entails up to twelve meetings (on average four), lasts on average twelve hours, and is generally carried out in groups of various sizes (from three to fifty). Trainers did not express particular difficulty (Q11, 64%); only one in four expressed a sense of inadequacy or poor preparation. During cascade training in schools, Internet connection was available (Q12, 94%) almost everywhere (Q13, 64), generally fast (Q15, 59), and continuously available (Q14, 62). Fewer computers (Q16, 42%) and very few tablets (12%) were available on average; almost all the participants had access to IWBs (84%), and one in four also had a projector.
- *Classroom teaching*: a vast majority (Q22, 73%) said they had already used some of the learned content, and one in five had done so frequently. Those who had not yet done so pointed mainly to an absence of Internet connection (Q24, 53%); one in three did not consider himself sufficiently prepared. Where classroom teaching was already underway, there were no structural obstacles: Internet access was available (Q30, 86%) almost everywhere (Q31, 72), often continuously (Q32, 65%) and fast (Q33, 65%); in the absence of Internet, personal connections were used. In almost all the cases (Q34, 86%), teachers could use IWBs, PCs (31%), projectors (26%) and tablets (11%).

The subsequent three twelve-month follow-up surveys confirmed almost entirely the results obtained at three months with two exceptions: those who had begun cascade training (Q5), which increased from 57% to 80%, and, despite stable rates for the use of methodologies and tools in the classroom (Q22) - which changed only from 73% to 76% - the share of those who used them frequently increased from 19% to 26%.

As a whole, 544 participants have been involved in the follow-up assessment process, 302 have been active respondents, with 200 coming from primary schools and 102 from secondary first-cycle institutions. One hundred seventy of 300 had launched the cascade training by three months after their training, involving close to 2,700 colleagues. This means that the estimated spread factor, due to the "evangelists'" actions, is close to sixteen.

This value exceeds the expected figures stated in the original plan, as preliminary estimation of the project impact initially put it at ten on average.

A separate program was also designed for managers and directors; that survey looked at the use and usability of digital tools for school management. The analysis focused on specific objective evidence, such as:

- recent changes in the three-year school Training Offer Plan (TOP) concerning improved digitization;
- use of application software for organizational management, teaching management, and managing relationships with students and families;
- provision of IT facilities in schools.

The questionnaire was assessed and validated by audit and inspections carried out by the project staff for the expected values estimated for infrastructure enhancement and application adoptions of digital solutions, as established by the project plan schedule.

C. SURVEY ON EFFECTS

The first survey on effect (at T1) was carried out between October 2019 and January 2020, on both teachers and first/second grade students. As previously mentioned, the objective of the survey is to verify if the (infrastructural and teaching) initiatives carried out during the project produced a change. The DiD technique requires two evaluations to draw conclusions on the effectiveness of the project activities. Nonetheless, for sake of completeness, in the following the preliminary results of the first survey are reported.

The first part of the teacher survey contains some general questions to better characterize the teacher (e.g., age, school type, etc.), and a set of 31 "non-digital" and "digital" questions. Table VII reports the result of teacher evaluation. From the results, it is possible to note that trained teachers provide generally 3% more correct answers than non-trained ones. An even more interesting result is that teachers trained with cascade training have these same performances. The same result can be seen in Table VII, where the analysis is performed by eliminating from the comparison some initial (observable) differences, such as age, school type, territory, etc. It must be said, though, that the difference between trained and non-trained teachers could be due to structural differences. Nonetheless, the fact that teachers trained in labs and trained with cascade learning presented similar performances could suggest the efficacy of cascade training.

TABLE 7. Results of teacher evaluation

	Not trained	Trained (labs)	Diff.	Trained (cascade)	Diff.
"Non-digital" questions	62.0%	64.7%	+2.7% ***	65.2%	+3.2% ***
"Digital" questions	67.1%	70.3%	+3.2% ***	70.2%	+3.1% ***
All the questions	65.5%	68.5%	+3.1% ***	68.6%	+3.1% ***
#	1.160	897		329	

Significant difference for *α=10%, **α=5%, ***α=1%

TABLE 8. Results of teacher evaluation (comparison under same conditions)

	Trained in labs VS not trained	Trained with cascade training VS not trained
"Non-digital" questions	+2.7% ***	+3.2% ***
"Digital" questions	+3.2% ***	+3.1% ***
All the questions	+3.1% ***	+3.1% ***

Significant difference for *α=10%, **α=5%, ***α=1%

Table IX and table X report the results of the survey carried out on first (19 questions) and second grade (27 questions) students, respectively. Students' results have been grouped on the basis of whether a teacher of their section (section training) or a teacher of their plexus (plexus training) participated in lab training. A third option (plexus fiber) identifies those students whose plexus was linked to optical fiber (but no teachers' training was carried out). The results also distinguish among students whose teacher never received training, or received training less than 3 months, between 3 and 8 months, or more than 9 months before evaluation.

TABLE 9. First grade student evaluation

	Never	<3 months	3-8 months	>9 months
Section training	61.2%	-0.7%	-0.5%	+1.7%
Plexus training	63.0%	-2.2%	-2.3% *	-0.7%
Plexus fiber	62.1%		-0.2%	-2.1%

Significant difference for *α=10%, **α=5%, ***α=1%

The results, differently from the survey performed on teachers, do not generally show significant statistical difference. With respect to these results, it must be said that, probably, it would be better to focus on students whose teachers received a training more than 9 months before the survey, as transferring new competences to students would probably require additional time than transferring them to teachers. Furthermore, it would be better to focus also on section and plexus training, as they are the ones in which the training initiatives took place. As for the first survey carried out on teachers, the results of the second evaluation will clarify whether this difference is due to structural difference in the sample.

TABLE 10. Second grade student evaluation

	Never	<3 months	3-8 months	>9 months
Section training	51.9%	-0.4%	+0.9%	+1.0%
Plexus training	51.0%	+1.5%	+1.5%	+1.6%
Plexus fiber	52.0%		-0.4%	+0.7%

D. DISCUSSION ON RESULTS

In the following, questionnaire results will be analyzed, by making reference to the paper's aims.

For what it concerns the definition of guidelines on how labs and workshops for improving teachers' digital competences could be organized, the evaluations provided by lab attendees highlighted the following strengths and weaknesses. First of all, the respondents underlined the fact that lab sessions devoted to planning their colleagues' training and students' training were not enough to carry out teaching initiatives (around 70% of respondents highlighted this weakness, respectively in FU-Q8 and FU-Q25). In fact, 50% of respondents (FU-Q9) and 46% of respondents (FU-Q26) stated that they had to provide additional efforts to deepen what was done in the labs, whereas 42% (Q9) and 41% (Q26) highlighted that they had to perform some partial adjustments to what was done in the labs. Hence, a first lesson learnt is that a) the time devoted to lab sessions should be increased; b) the topics addressed during the labs should be deepened. With these modifications, hopefully the 15% of teachers that were not able to train their colleagues because they were not prepared on the course topics, as well as the 11% because of their inadequate background (FU-Q11), would become more skilled for this task. Concerning workshops' and labs' structure, respondents asked for more (hands on) gaming (25%), more group discussion (10%), and less front lessons (17%) (FB-Q5). Detailed answers for the different workshops provided in FB-Q4 highlighted a marked need for more technology, especially for Riconnessioni workshop (53%), Creating digital content (42%) and Computational Thinking (40%). Hence, a second lesson learnt is that c) "traditional" frontal lessons should be reduced in order to increase other learning/discussion modalities, and d) the workshops/labs should deepen technological aspects.

For what it relates the impact of training initiatives on teachers' competences and on teaching modalities in classrooms, 70% of the attendants confirmed that they often/sometimes used what they learned during labs for classroom work with students (FU-Q22). They maily used acquired knowledge for various disciplines (50%), or for multiple topics within a single discipline (27%) (FU-Q23). Those who did not use what they learned during labs mainly felt they were not ready (34%), or reported internet unavailability (50%) (FU-Q24). Concerning experiential teaching methods, 82% applied them often/sometimes (FU-Q27) in the same situations (with the same percentages) reported in Q23. Interestingly, those who did not apply them highlighted, apart from not feeling sufficiently skilled, that students were not receptive (31%) (FU-Q29). Nonetheless, when digital content was used, students were either active (51%) or enthusiastic (32%) (FU-Q39). Finally, an interesting feedback provided is that teachers feel that the participation in Riconnessioni project changed the way they teach, for the contents of the teaching (28%), for the teaching methods (36%), for both of them (18%) (FU-Q40), with a slight majority of teachers who changed students' learning assessment methods (53%) (FU-Q41). Hence, Riconnessioni training initiatives had an impact on the way teachers convey content to the students, for nearly three teachers out of four, a number which could be increased by devoting additional training time for teachers, making them feel more skilled, as discussed above. An additional lesson learnt is that e) workshop/labs should increase the time devoted to teach/discuss on instruments and techniques to make students more receptive to new teaching modalities.

Concerning the evaluation of the effects of the cascade training, it must be underlined that preliminary results are not sufficient to confirm if the cascade training had an impact on the competences of teachers who did not attend labs/workshops, since the DiD technique requires a second evaluation, planned for the beginning of 2021. Nonetheless, it must be noted that both teachers trained in labs and teachers trained with cascade training had similar performances, with +3% of correct answers provided ($\alpha = 1\%$). While the second evaluation performed at T2 will clarify this aspect, this preliminary result is encouraging.

VI. CONCLUSIONS AND FUTURE WORK

The future of technology in education is not technology by itself but predominantly leadership skills. The transformation process must be initiated from above, that is, by the School Head and the Institute Council over which he presides. It is crucial that the latter understands the value and urgency of the transformation and how it can be shared by all the parties involved. Leadership must support the use of technology and almost insist on guiding the institution in the use of technology everywhere, from social media to the school records and the library. There is no doubt that e-learning, the number of online courses launched, and "one-to-one computing" are changes having high systemic impacts.

In this context, the present work has described the "Riconnessioni" project addressing the construction of an ecosystem for learning, oriented toward "doing" and experiencing in a reference framework subject to the dynamics of the digital transformation of processes, also proposing itself as one of the most shared initiatives inspiring and building the foundation of a new education ecosystem.

To date, since the project is in the second progression year of three, more than 150 primary and first-cycle secondary schools have been involved through their 550 teachers chosen to inform the roots of a renewed education landscape. The infrastructure created with Riconnessioni is the starting point for a revolution in education and management of schools. Digital transformation is not an end in itself but has been used as an enabling factor for broader change in the school, enhancing learning inclusion and creativity.

Technology-based topics have led to the identification of six themes that structure as many lab paths. As of November 2019, labs have already hosted more than 550 teachers, who, in turn, have become "evangelists" to pursue a cascade training process, which to date has trained more than 2,600 colleagues. The "evangelists" have attended the Riconnessioni lab to develop a culture of self-assessment by focusing on digital skills, while the Computational Thinking lab has enhanced their logical reasoning and problem-solving skills, also sustained with an introduction to programming and robotics. The Creating Digital Content lab addresses tools for creating digital content at no cost and experimenting with analog-digital hybrid approaches to enhance creativity, while the Being Digital lab was shaped to overcome digital prohibitionist perspectives in favor of conscious use of tools, of one's own virtual identity and privacy. The Innovative Teaching and Inclusion lab was developed to explore the inclusive potential of new technologies in working with heterogeneous class groups and networking of schools and associations. Extensive quantitative and qualitative assessments have been put in place and presented here to monitor processes and results while the project is still in progress to achieve completion by the beginning of 2021. The project's main achievements, in addition to the infrastructural domain improvement, are a) the definition/evaluation of training initiatives, able to improve teachers' competencies in the digital domain; b) the exploitation of cascade learning, which is shaping the real impact of the project in terms of self-sustainability. In fact, thanks to training initiatives, three out of four teachers felt comfortable in transferring to their colleagues the knowledge acquired during labs/workshops. On the basis of data collected with the follow-up survey, the spread factor value has been calculated as sixteen, thus exceeding the original project target estimate of ten on average.

The Riconnessioni project highlighted that a systemic intervention targeted to improve both infrastructural domain and teachers/school staff competence could help enhance the existing training offer. Furthermore, the project underlined the key role played by teachers in being "evangelists" of new technologies, innovative learning models, and tools helping their colleagues master digital domain knowledge and awareness.

Future planned work concerns the execution of the DiD effects assessment, already established in terms of a set of questions. The first delivery has already been carried out between October 2019 and January 2020, and the final retest is scheduled for the beginning of 2021.

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