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Lifelong Learning Programme

MLEARN

training teachers to use mobile (handheld) technologies within mainstream school education

Schools Case Studies Report

www.mlearn-project.eu

PROJECT REFERENCE NUMBER: 539357-LLP-1-2013-1-UK-Comenius-CMP

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Contributi multimediali a cura di Cecilia Stajano

Fondazione Mondo Digitale

www.mondodigitale.org

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Introduction

The 2-year M-LEARN project "Training teachers to use mobile (handheld) technologies within mainstream school education" is a COMENIUS multilateral project that aims to introduce mobile technology (tablets) into schools, challenging teachers to think creatively and develop and experiment with new approaches and didactic methodologies across different subjects. The project involves 6 partners in 5 countries and responds to policy recommendations in the JRC Scientific and Policy Report "Key Elements for Developing Creative Classrooms in Europe"; and ET2020 Objective 4 concerned with enhancing innovation and mainstreaming the use of ICT in national policies and practices.

1 teacher per country participated in the 5-day training programme in the United Kingdom conducted by experts in the use of ICT for school didactics. In each country the trained teacher, supported by partner organisations, trained other trainers through an initial programme of 16 hours followed by 16 additional hours of more hands - on activities accompanying the start of the experimentation in classes.
In Italy, 10 schools from different levels and technology proficiencies were involved in the pilot project and classes were equipped with 1 tablet for every 4-5 students.

The school case studies explore the implications and impact of the adoption of ICT within schools, examining the outcomes of innovation in pedagogical practices from the teachers' and the students' perspectives, regardless of the different approaches adopted by the schools while introducing the new technologies.
Visits to the schools and interviews were carried out to observe schools' best practices leading to the drafting of this report on developing and mainstreaming the overall school approaches to ICT.
While infrastructure issues, such as access to an adequate number of devices, reliable Internet connectivity and adequate technical support, were important elements in the introduction of ICT in schools, the pilot project's

outcomes were mostly determined by the commitment of teachers to fully overcoming their personal lack of confidence in using ICT as well as their fear of changing traditional teaching methods.

The work presented in this publication is supported by the European Commission's Life Long Learning Programme – project **MLEARN - Training Teachers to use mobile (hand held) technologies within mainstream school education** (reference number 539357-LLP-1-2013-1-UK-Comenius-CMP). The content of this document is the sole responsibility of the Fondazione Mondo Digitale and it does not represent the opinion of the European Commission and the Commission is not responsible for any use that might be made of the information contained herein.

European schools' experience in using computers/internet

According to data reported by the Italian government in 2015 in the document "The Good School", to date, "only 10% of our primary schools, and 23% of secondary schools, are connected to the Internet via a fast network. The other institutions are connected to medium-low speed networks, but with very different situations, often the network is sufficient only to connect the secretarial office, or technological laboratory; almost in one school every two (46%), the connection does not reach the classes and therefore does not allow any of the innovative teaching, that the network could enable". More than half of classes in Italy, therefore, cannot apply methodologies for digital learning.

The minimum standard for a highly digitally equipped school is the availability of a fast broadband Internet connection (10 Mbps or more) and high connectivity (for example, having a web site, email, a virtual learning environment and a local area network). According to the results of the survey conducted by the European Commission DG Communications Networks, Content & Technology Survey of Schools: ICT in Education Benchmarking Access, Use and Attitudes to Technology in Europe's Schools (2013), across the EU, 37% of students at primary school level, 24% of students at the secondary school level, and 55% of high school students, attend highly digitally equipped schools.

There are significant differences between countries in terms of percentages.

On average, in the EU one computer is available every 3-7 student; the number of students per computer is higher in primary schools than in secondary schools in most countries. Denmark, Norway and Spain have an average of 3 students per computer; in 10 other European countries, on average, one computer is available every 4-7 students; Italy has an average of 16 students per computer; only Greece, Romania and Turkey report a higher number of students per PC (between 16 and 20). Only 10% of Rome school establishments have a PC for less than 5 students.

Fig. 1.9a: % of students in schools without broadband
(Grade 4, country and EU level, 2011-12)

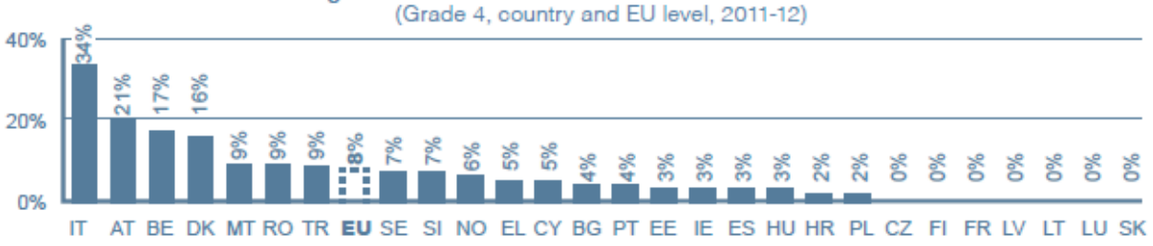


Fig. 1.9b: % of students in schools without broadband
(Grade 8, country and EU level, 2011-12)

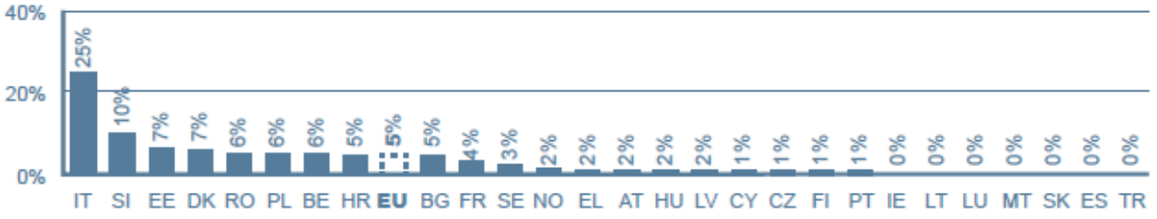


Fig. 1.9c: % of students in schools without broadband
(Grade 11 general, country and EU level, 2011-12)

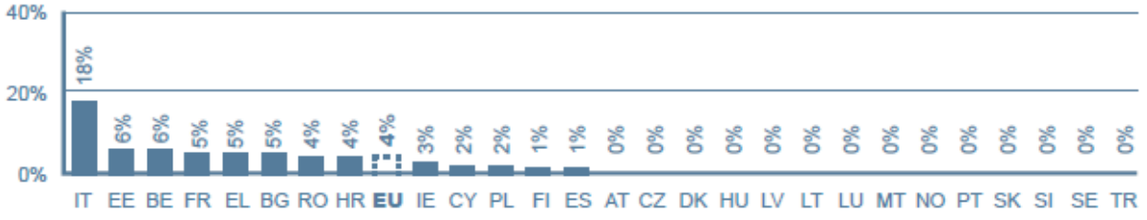
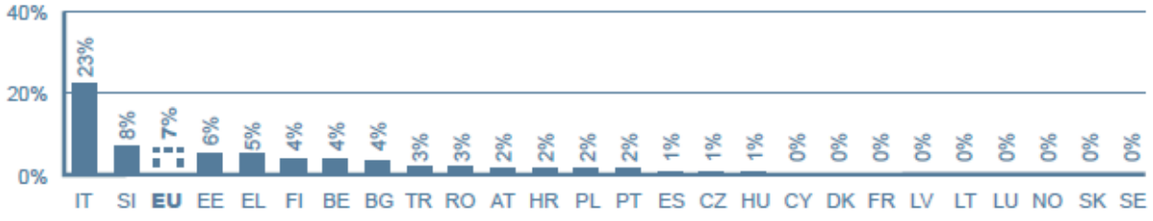


Fig. 1.9d : % of students in schools without broadband
(Grade 11 vocational, country and EU level, 2011-12)



Source: P. 46 European Commission DG Communications Networks, Content & Technology Survey of Schools: ICT in Education Benchmarking Access, Use and Attitudes to Technology in Europe's Schools (2013)

Laptops, tablets and netbooks are becoming more common, but only in some countries; on average, in the EU there are between 8 and 16 students per laptop.

In Europe, on average, more than one student of every two at the secondary school level use school computers for studying purposes at least once a week. Based on the European average, 64% of secondary school students use computers at least once a week. 14 countries are above the EU average, Italy is among the countries whose rate is below average.

Approximately 64% of European students at secondary school level use their mobile phone for studying purposes, and 16% use their laptop for the same purpose, at least once a week. Italy, the fourth from the bottom, reports that respectively 37% and 13% of students, use their mobile phone or laptop to study at least once a week.

The European average of students in secondary high schools who use interactive whiteboards at least once a week is 20.9%, the average is 21% in Italy, over 50% in Slovenia, the Czech Republic and Latvia. 84% of laboratories of the schools in Rome are not equipped with interactive whiteboards.

20% is the average of students in the first grade of secondary school who never used a computer during a lesson in the last year in Europe. Italy ranks among the five countries with the highest percentage (26%) of students from the secondary school level who never used a computer during a lesson last year.

21% is the average of students in secondary high schools who never used a computer during a lesson last year in Europe. Italy, with 42%, is the European country with the highest number of students in secondary high schools who never used a computer during a lesson last year.

Fig. 2.8a: % students 'never or almost never' using a computer in lessons in the last year
(Grade 8, country and EU level, 2011-12)

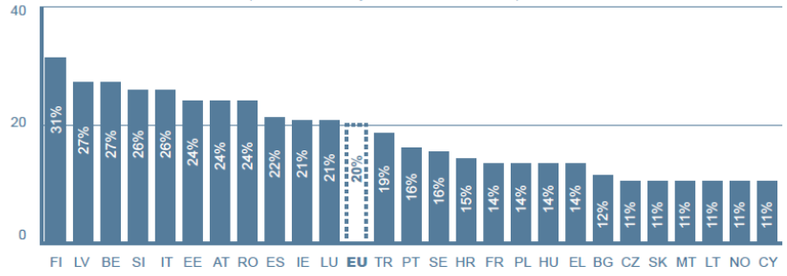


Fig. 2.8b: % students 'never or almost never' using a computer in lessons in the last year
(Grade 11 general, country and EU level, 2011-12)

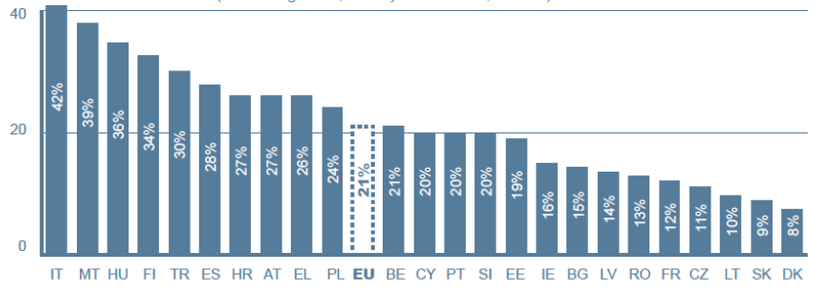
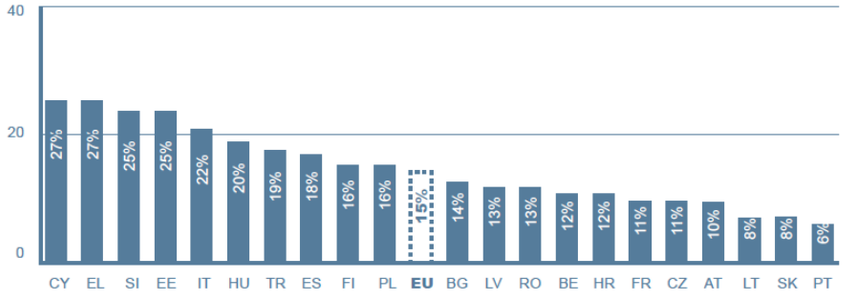


Fig. 2.8c: % students 'never or almost never' using a computer in lessons in the last year
(Grade 11 vocational, country and EU level, 2011-12)



Source: P. 64-65 European Commission DG Communications Networks, Content & Technology Survey of Schools: ICT in Education Benchmarking Access, Use and Attitudes to Technology in Europe's Schools (2013)

In Europe, at the level of the first and second grade of secondary school, the three countries where head teachers blame the insufficiency of equipment as the primary cause for failing to use technology while teaching, are the same where the ratio of number of students and number of PCs is higher. Italy is among these countries.

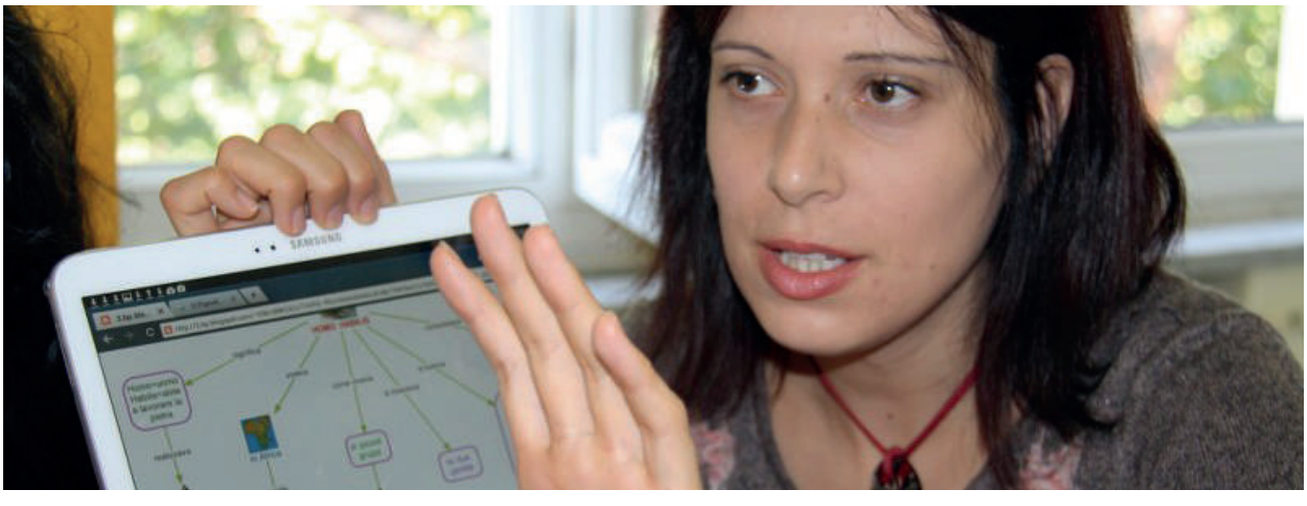
In Europe more than 9 students out of 10 attend schools with broadband, typically from 2 to 30 Mbps. The lack of access is particularly relevant in Italy, compared to all other countries.

The European average of primary school students who attend highly digitally equipped schools is 37%. 14 countries reported a higher average. In Italy, less than 10% of primary school students attend such schools. Only five other countries report such a low average.

The European average of secondary school students of the second degree attending highly digitally equipped schools is 24%. In Italy less than 5% of students attend such schools, while more than 60% attend poorly digitally equipped schools (the European average is 8%). 55% of European high school students attend highly digitally equipped institutions, In Italy about 30% of students attend such schools.

In addition to poor technological equipment, obstacles to the use of technology for teaching and learning, in Italy more than in other European countries, are: lack of content, teachers' lack of technical skills, and difficulties in integrating ICT in teaching.

Across the EU, 75% of students follow classes run by teachers with more than four years of experience in the use of ICT at school. Teachers with less than one year of experience in the use of ICTs are extremely rare. 30-45% of students follow lessons given by teachers who use ICT for teaching every day or almost every day, or at least once a week. 30% of students use the school website or the virtual learning environment every day or almost every day, and 20% of students use the school website or the virtual learning environment and digital resources at least once a week. On average, in Europe, 27% of primary school students attended a school with a virtual learning environment, 61% of students enrolled at the first and second grade of secondary school, attended, on average, an institute with such a learning environment. In Italy, 10% of primary school students, 19% of students enrolled in the first grade of secondary school, and 33% of students enrolled in the second grade of the secondary school, attended an institute where a virtual learning environment is available. 74% of Rome's schools do not use the web environment.



Source: European Commission DG Communications Networks, Content & Technology Survey of Schools, ICT in Education Benchmarking Access, Use and Attitudes to Technology in Europe's Schools (2013); European Schoolnet and University of Liège, Survey of Schools: ICT in Education Country Profile: Italy (2012)

Digital equipment in the Municipality of Rome schools

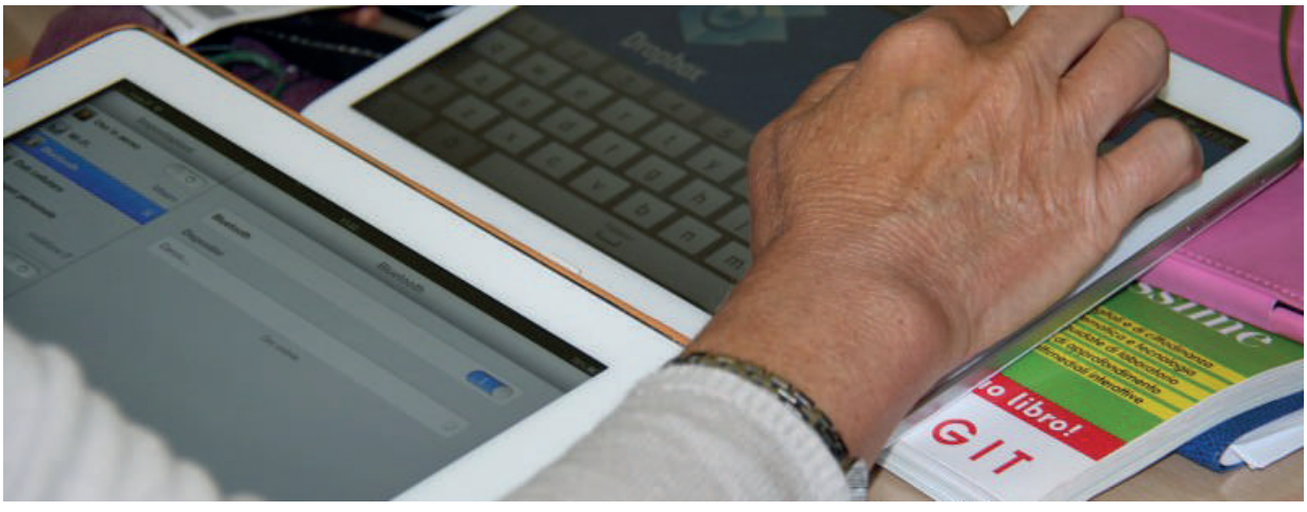
The 10 schools involved in MLEARN piloting are all located in the area of the Municipality of Rome. In the 2013/2014 school year, there were 310 schools in Rome including kindergarten, primary and secondary schools. 269 of these responded to the questionnaires submitted by the Statistics Office of the Ministry Education, University and Research, for the collection of data used and processed by the Fondazione Mondo Digitale.[1] Of the 269 schools that participated in the survey, 9 result not equipped with laboratories with WiFi connectivity, 47 institutes have poor connectivity, 76 have medium connectivity, and 137 institutes have laboratories connected via WiFi.

The European benchmark for a highly digitally equipped school dictates that a school should have relatively high equipment levels, fast broadband (10mbps or more) and high connectedness (e.g. having a website, email, a virtual learning environment and a local area network). According to the findings, across the EU, 37% of primary school students, 24% of students enrolled in the final grade before high school, 55% of students enrolled in the final grade of high school (grade 11) attend such schools. There are great differences between countries in terms of percentages in high and low levels of such schools. More than 9 out of 10 students are in schools with broadband, generally from 2 to 30Mbps, on average in the EU. Most schools are connected at a basic level, that is, having a website, email for students and teachers or a virtual learning environment.[2]

[1]A.Molina, A.Mazzucato, *Innovazione nella scuola romana: dotazione digitale e proposte formative della Città Educativa di Roma*, Fondazione Mondo Digitale, 2015.

[2]European Commission DG Communications Networks, Content & Technology, *Survey of Schools, ICT in Education Benchmarking Access, Use and Attitudes to Technology in Europe's Schools*, European Commission 2013.

Equipment in Rome's school laboratories is very uneven: 8% of schools and school complexes have less than 20 PCs; 31% have more than 20 PCs up to a maximum of 40 PCs, 49% benefit from more than 40 PCs up to a maximum of 100 PCs, and 31% are equipped with more than 100 PC.
Within school complexes, 31% of classrooms are not equipped with PCs, 59% have approximately 20 PCs, 8% of classrooms have a number of PCs between 21 and 40, 2% are equipped with more than 20 PCs up to a maximum of 100.
Considering the number of students compared to the number of available PCs in labs and classrooms, it appears that 10% of schools have at least one computer every 5 students; 16% at least one PC every 6-10 students; 39% are equipped with 1 PC every 11-20 students. 35% of schools have 1 PC every 20 or more students.
74% of schools do not use the web environment. In 6% of schools where it is available, the web environment is not accessible to teachers. In 80% of schools where it is available, the web environment is accessible by students.
16% of schools' laboratories are not equipped with Multimedia Interactive Blackboards. 35% of classrooms in school complexes do not offer this equipment.



In Italy most computers are desktop computers rather than laptops, however Italy ranks among the countries with the lowest percentages of students having access to internet-connected desktop computers in Europe attending the final grade before high school. In terms of internet-connected laptop computers at the final grade before high school, Italy is among the bottom group of countries, and the situation is the same at all levels.[3]
In Europe there are on average between 3 and 7 students per computer; the older the student the lower the student to computer ratio in most countries; on average in the EU there are between 8 and 16 students per laptop at grades 4 and 11 (vocational) respectively.[4]
Schools involved in the M-LEARN project have medium broadband connectivity. Laboratories are equipped with Multimedia Interactive Whiteboards and projectors. Only 1 school is equipped with handheld technologies (12 mini tablets).

[3]European Schoolnet, University of Liège, *Survey of Schools: ICT in Education Country Profile: Italy*, European Schoolnet, 2012.
[4]European Commission DG Communications Networks, *Content & Technology, Survey of Schools, ICT in Education Benchmarking Access, Use and Attitudes to Technology in Europe's Schools*, European Commission, 2013.

National curriculum or guidelines regarding the use of handheld technologies for teaching and learning

In Italy the Ministry of Education, University and Research is responsible at the national level for the direction of the education system and curriculum, including subjects on the annual programme of all school levels, the programme and hours to be dedicated to the teaching of each subjects and the criteria for students' learning outcomes assessment. Each school institution is managed by a head teacher as legal representative and civil servant, who has autonomy within the national framework over the institutes' financial and material assets and the quality of the didactics offer.

The National Institute for Documentation, Innovation and Educational Research - INDIRE, belongs to the Ministry of Education, University and Research and it is the main reference at the national level for the teacher training offer. Its mission is to support the evolution of the scholastic system investing in research, training and innovative projects to enhance school renewal and innovation.

Together with INVALSI, the National Institute for the Evaluation of Education and Training, INDIRE is part of the Ministry's educational evaluation system, monitoring the quality of the national educational system and proposing several initiatives for school innovation and teachers training. In 2009, the Institute supported the Ministry's School 2.0 initiative, providing teachers with training on the didactic use of Multimedia Interactive Whiteboards provided to all schools' classes in Italy as part of a national plan for the diffusion of ICT in schools.

INVALSI is a national research body entitled by the national legislation to conduct periodic and systematic evaluation at the national level of the schools' didactic offering at all levels and of students' learning outcomes, as well as to report on general and specific levels of students proficiency on different subjects of the mainstream curriculum.

In 2015, the Italian government approved "The Good School" (Law 13 July 2015, n.107) defining guidelines to start a substantial change of Italian schools in alignment with the most successful European experiences. The strategy would encourage institutes to autonomously develop three-year didactic plans, including both curricular and extracurricular activities. Within the resources assigned, high schools would also have the independence to introduce subjects not already part of the mainstream curriculum, personalising didactic offerings to students' needs.

Digital literacy ranks among the key issues on which to build new solutions, with the aim of "a constant updating of the educational system, for the benefit of what our kids learn at school". The document indicates that the teachers' digital training deserves special attention. To implement integrated and modern teaching, teachers must be offered adequate training and tools which offer them flexibility and allow them to support inclusive, creative and innovative educational activities. An extraordinary plan is foreseen to endow all institutes with adequate broadband connection.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Teachers' experience in using ICT at school

In Italy, teachers' self-confidence concerning their operational skills with ICT is near to the EU mean at all grades. A large majority of teachers in Europe have been using computers/internet at school for at least four years, and the Italian average is close to the European percentage[5].

Fig. 4.1: Teachers' self-confidence in their ICT skills

(by grade; mean score of students with 1 being 'none' and 4 being 'a lot'; Italy and EU; 2011-12)

Fig. 4.1a: grade 4

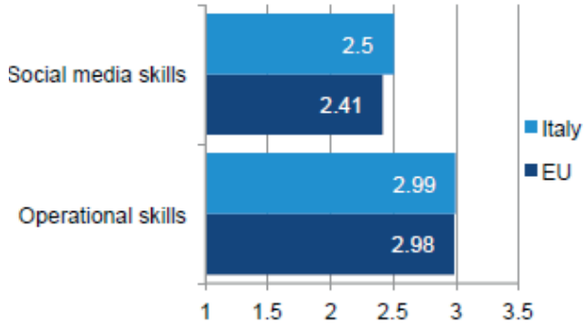


Fig. 4.1b: grade 8

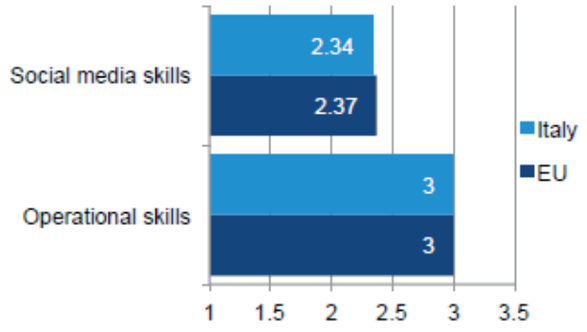


Fig. 4.1c: grade 11 gen.

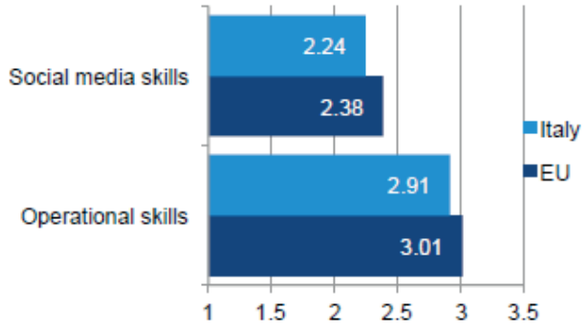
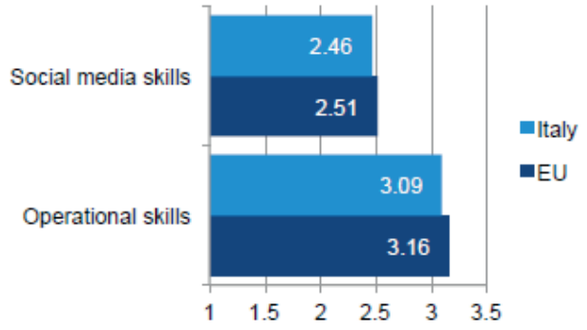


Fig. 4.1d: grade 11 voc.



Source: P. 64-65 European Commission DG Communications Networks, Content & Technology Survey of Schools: ICT in Education Benchmarking Access, Use and Attitudes to Technology in Europe's Schools (2013)

[5] European Commission DG Communications Networks, Content *& Technology, Survey of Schools, ICT in Education Benchmarking Access, Use and Attitudes to Technology in Europe's Schools*, European Commission, 2013.

Fig. 3.2a: Teachers' experience in using computers/internet at school, at grade 4
(In % of students, by country, 2011-12)

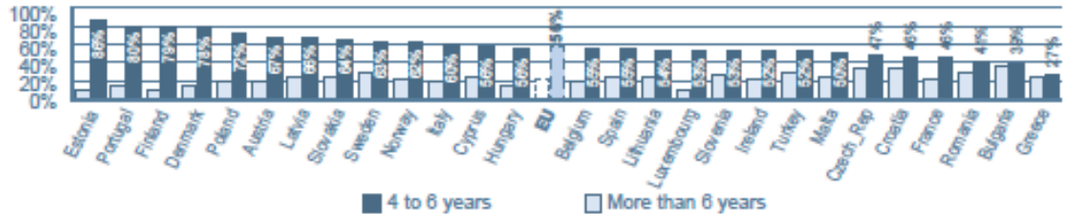


Fig. 3.2b: Teachers' experience in using computers/internet at school, at grade 8
(In % of students, by country, 2011-12)

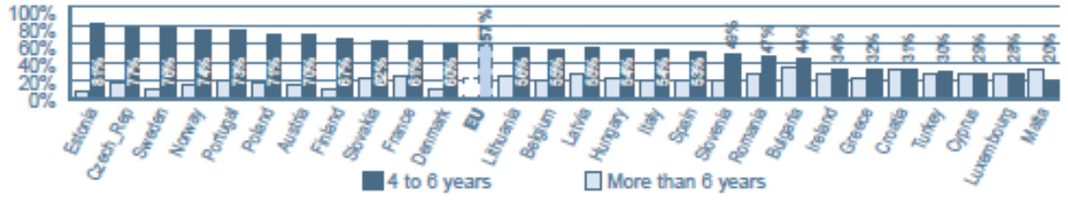


Fig. 3.2c: Teachers' experience in using computers/internet at school, at grade 11 general education
(In % of students, by country, 2011-12)

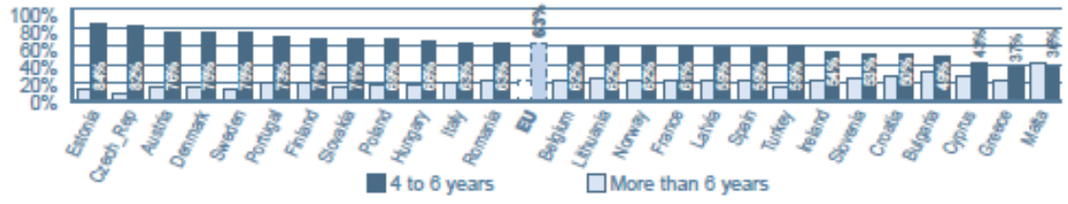
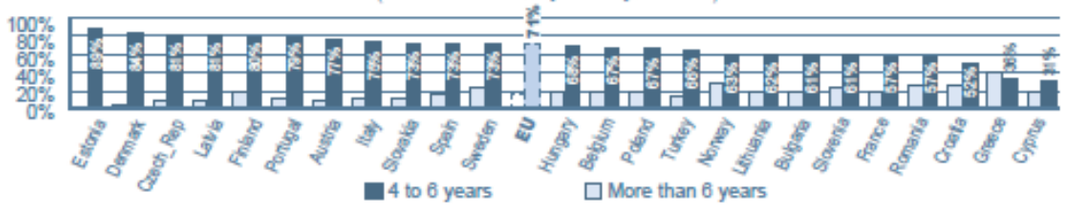


Fig. 3.2d: Teachers' experience in using computers/internet at school, at grade 11 vocational education
(In % of students, by country, 2011-12)



Source: P. 64-65 European Commission DG Communications Networks, Content & Technology Survey of Schools: ICT in Education Benchmarking Access, Use and Attitudes to Technology in Europe's Schools (2013

The focus groups conducted with 22 schools' teachers taking part in the MLEARN projects at the beginning of the training programme revealed that most of them had used digital technologies in their teaching before, largely interactive whiteboards, projectors and PC, rarely experimenting with handheld technologies in class apart from laptops. Approximately half of interviewed teachers declared to be aware of the possible uses of handheld technologies for teaching and learning and generally, most of them expressed a lack of confidence in applying such devices to the mainstream school curriculum.

Most of teachers never received professional training related to the use of ICT for teaching and learning, and felt that training support would be required in order to start introducing the use of ICT in their teaching, both related to the technical use of devices and available applications as well as to pedagogical aspects required to

change teaching methodology within the class.

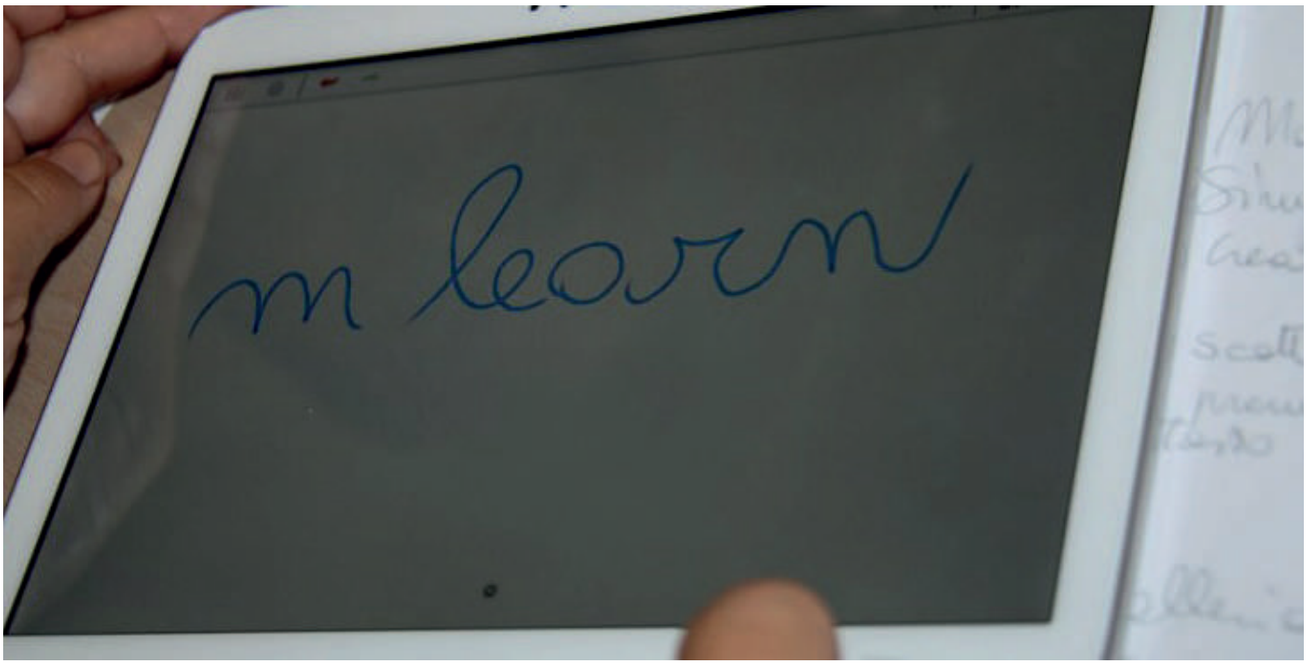
Practical hands-on activities are considered the most suitable path for teachers to gain confidence and introduce handheld devices in their daily teaching, providing students with the adequate support to approach technologies with awareness regarding their benefits and risks in order to become active users and learners.

The MLEARN training programme has been developed based on teachers' needs, recognising that the adoption of ICT requires a good students-equipment ratio, teachers' sufficient ICT skills to make use of technology and feel confident enough to use it in a classroom setting, and teachers' insights into the pedagogical role of ICT in order to apply it meaningfully in their teaching.

The resulting 32-hours training programme combined frontal lessons, practical activities aiming at exploring potential activities to be carried out in class and applied to the mainstream curriculum, as well as concrete experimentation with the use of handheld technologies in class during school hours.

Teachers were equipped with 1 tablet every 4-5 students, together with devices for content sharing through connection with the projector and interactive whiteboard. Each teacher conducted the experimentation with 1-2 different classes of 25 to 30 students, from primary to secondary school, introducing handheld technologies for teaching and learning through different subjects of the school curriculum.

Periodic meetings with teachers and students were conducted in order to monitor the training's impact. The first 8 plus 8 hours of frontal lessons were sufficient to familiarize teachers with the practical use of the devices and different applications, but not to make them feel comfortable in fully integrating technologies in their teaching. By the end of the 16 hours of theory training combined with practical activities, teachers felt confident in introducing the devices in class from 1 up to 5 times a week, exploring new pedagogical approaches, claiming to be fully convinced about the positive role of technology in education and well aware of its potential for learning. During the piloting, additional teachers joined the project, trained by their colleagues, for a total of 30 teachers by the end of the project.



At the end of 12 months of experimentation in class, the 30 teachers felt confident in the use of ICT for teaching and learning and changed the way lessons as well as students' home study are organized.
The motivation that encouraged teachers to take part in the project was the desire to update their skills and innovate mainstream didactics, re-orienting schooling from the repetition of individualistic learning to collaborative, life-skills learning.

The MLEARN project experience

Innovate traditional pedagogical approaches

The pedagogical practices of teachers piloting the integration of handheld technologies in the curriculum gradually changed during the experimentation, accompanied by an increased familiarity in the use of ICT, from small enhancements of traditional practices to more essential changes in their approach to teaching.

In the attempt to integrate ICT effectively into teaching, learning and the curriculum, teachers experienced different phases: they became aware of the potential of handheld resources both in terms of their contributions to pupils' thinking and in terms of extending their learning in specific subjects; they became able to select the appropriate applications to meet students' specific learning objectives on different subjects; they developed the ability to prepare and plan lessons using handheld technologies targeting change in pupils' understanding and reflection; they acknowledged different class-organisation methods, which are most effective for learning tasks applying ICT.

The pedagogical reform triggered by the introduction of handheld technologies encouraged teachers to complement their traditional lessons, either providing new ways of handling information or making presentations more attractive. This stimulated a student-centred approach to teaching and learning[6], shifting the focus of instruction from the teacher to the student, developing learners' autonomy and sense of responsibility in their learning path.[7] By focusing more on developing skills practices rather than on repeating and memorizing the lesson given by the teacher, this approach facilitates lifelong learning and independent problem-solving.[8] Constructivist learning accentuates learners' critical role in building meanings, combining new information with prior knowledge derived from experience.

[6] B. McCombs, J. Whistler, *The learnercentered classroom and school: Strategies for increasing student motivation and achievement,* Jossey-Bass Publishers, 1997.

[7] D. J. Nicol, D. Macfarlane-Dick, *Formative assessment and self-regulated learning: a model and seven principles of good feedback practice*, Studies in Higher Education, 2006.

[8] J. L. Cooper, MacGregor, Smith, & Robinson, J. L. Cooper, J. MacGregor, K. A. Smith, P. Robinson, *Implementing Small-Group Instruction: Insights from Successful Practitioners.* New Directions in Teaching and Learning, 2000.

I. C. W. A. Mozart - Roma
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As one teacher said: "students create their own knowledge, they shape concepts not previously given, elaborating the lessons learnt from their concrete experiences… Students were recipients of information given by teachers, to memorize and accept, while the introduction of handheld technologies allowed the development of new learning activities that promote students reflection and critical judgement of what they are studying…".

Student-centred learning prioritizes students' learning experience, acknowledging their active role in the development of the learning process throughout practicing skills.[9]

With MLEARN, the curriculum was re-organised in project-based activities rather than on single subjects, linking different subjects. In a student-centred classroom, the teacher has to develop a personalised path to learning, allowing students to independently choose the way to build their knowledge. Classes were no longer organised in traditional, teacher-led lessons, since students were engaged in the role of trainers of their peers, working in groups where roles are interchangeable.

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Knowledge became multidirectional and the classroom was flipped: teachers no longer delivered lectures and the students became active contributors in lessons, preparing materials and presentations to deliver to the class. Learners engaged in common tasks such as collaborative writing, group projects, joint problem solving, debates, study teams, and other activities where each of them depended on the others to accomplish the results. Working

[9] D. H. Jonassen, *Objectivism versus constructivism: do we need a new philosophical paradigm?* Educational Technology Research and Development, 1991.

collaboratively, students exchanged information with their peers[10], capitalizing on one another's knowledge. Again, in the collaborative learning methodology, the traditional student-teacher relationship is redefined. The cooperative learning approach also enhanced the socialisation, integration and teamwork within the class of students, since they reached the learning goal and a positive result when they were able to pursue outcomes that were valuable to themselves as well to their peers.

As a teacher said: "tablets allow us to organise the students' project-based team work … students are responsible for deciding how to organise tasks and allocate responsibilities to reach the results…".

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The pedagogical approach underlying the project-based collaborative organisation of the class and the way the different curriculum subjects are dealt with,[11] generally promoted a learning path where students were encouraged to formulate questions, find solutions, analyse information and reformulate knowledge, rather than simply presenting memorized facts.[12] This enquiry-based learning process was facilitated by the teacher supervising the selection of sources of information, mediating teamwork so as to ensure balanced participation of all students, and offering suggestions to guide students through the development of the solution to the given challenge.[13]

[10] Michaelsen, Knight and Fink (2004) L. K Michaelson, A. B. Knight, L. D Fink, *Team-Based Learning: A Transformative Use of Small Groups in College Teaching*. Sterling, VA: Stylus Publishing, 2004.

[11] C. P. Lim, S. Barnes, Those who can, teach" - *The pivotal role of the teacher in the information and communication technologies (ICT) learning environment*, Journal of Educational Media, 2002.

[12] C. C.Bonwell, J. A. & Eison, *Active Learning: Creating Excitement in the Classroom,* George Washington University Press, 1991.

[13] D. W Johnson, R. T Johnson, K. A. Smith, *Active Learning: Cooperation in the College Classroom*, Interaction Book Company, 1991.

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As a teacher said: "working in groups with their peers, students feel freer to formulate questions, discuss possible solutions with others … it seems that within this class setting, students feel more proactive and free to express their opinion…". Furthermore, as another teacher pointed out: "students usually less motivated to study, clearly demonstrate active engagement and curiosity… it appears that it's easier for them to build up their knowledge when information comes from their peers, rather than from the teacher… also students tend to remember more content when they find their own way to develop understanding and engage in the research and development of materials...".

Furthermore, embedding handheld technologies in the curriculum, content delivery was often moved outside of the classroom, extending the traditional boundaries of schools, using videos or presentations reviewed more than once. This also allowed for more class time to be spent on engaging learning activities such as peer instruction or active learning,[14] applying interactive teaching techniques that conveyed more engaging and attractive lessons. Free from the central role of lesson supplier, the teacher also had more time to assist students with special learning needs.

In this framework, differentiated learning and assessment methods also supported different routes to learning, providing students with several scenarios to find their own way to research and process content, so that all students within a classroom learn more effectively, regardless of differences in abilities.

The use of handheld technologies, in fact, facilitated the differentiation of teaching and learning methods, significantly altering expectations for task accomplishment as to meet pupils' learning needs and achievement of their learning goals. Differentiated classrooms became more inclusive regarding interests, learning profiles, culture, socioeconomic status, language, gender, motivation and ability/disability.

[14] E. Mazur, *Peer Instruction: A User's Manual*, Prentice Hall Englewood Cliffs, 1997.

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Impact on learners' skills and competences

Evidence gathered during the interviews of teachers and parents showed a direct link between ICT and the learning environment. ICT-rich, constructivist learning environments improved students' learning outcomes, especially for students with lower skill levels and weaker competences or from diverse cultural backgrounds. To access, extend, transform and share represent key processes by which students learned and became independent learners and self-starters.

Where the student learning process had been problematic and the motivation to learn low, ICT had a direct impact on encouraging pupils to engage in learning, in most cases raising the participation during lessons and the overall attainment level, leading to scores enhancement.

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Changes in the curriculum pedagogy, accompanying ICT use for teaching and learning, encouraged students to be more creative and independent thinkers and learners. Differentiated learning and assessment stimulated students to take more responsibility for their learning, introducing them to the enjoyable sides of researching, understanding and creatively developing their own knowledge.

As a teacher said: "…students with low proficiency or disaffection for studying, showed a surprisingly renewed active participation in the lesson when using handheld technologies … they were willing to discover, looking for new information with an enthusiastic attitude…".

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The pedagogical advantage of instructional multimedia lies in its use of the natural information-processing capabilities that we already hold as humans. As a teacher observed: "…lower level kids who are usually hesitant to complete a research or write an essay ... jump on the opportunity to write on the laptop or collecting pictures for the research...".

For instance, during the school piloting, the application of a flipped classroom or peer tutoring methodologies showed a strong potential in narrowing the existing performance gaps between students with different scores. As a teacher said: "…students understand more easily a concept or subject if it is explained by a peer, using a common mean of communication that appears to be based on common interests … they have so much fun working together and it is easier for them to accomplish results, sharing the tasks and finding out about each other interests and competences…".

In other words, as another teacher pointed out: "…an assignment on paper could be a challenge for some students…but when it can be done on the tablet it becomes more interesting, giving the student more motivation to try…". Similarly, drill and practice exercises supported by handheld technologies also provide differentiated opportunities for learners to change their understanding and knowledge of a topic to be learned.

Generally, teachers reported that open learning allowed them to attract students at both ends of the academic spectrum, however, as a head teacher added: "…some teachers felt that students with higher academic skills learn more effectively when using new technologies, but the application of ICT motivate the weaker students more, and in some cases students with lower academic skills demonstrated advanced ICT skills … ICT gave them the opportunity to experience success in front of the class…and they felt more motivated to study and more self-aware of their abilities…".

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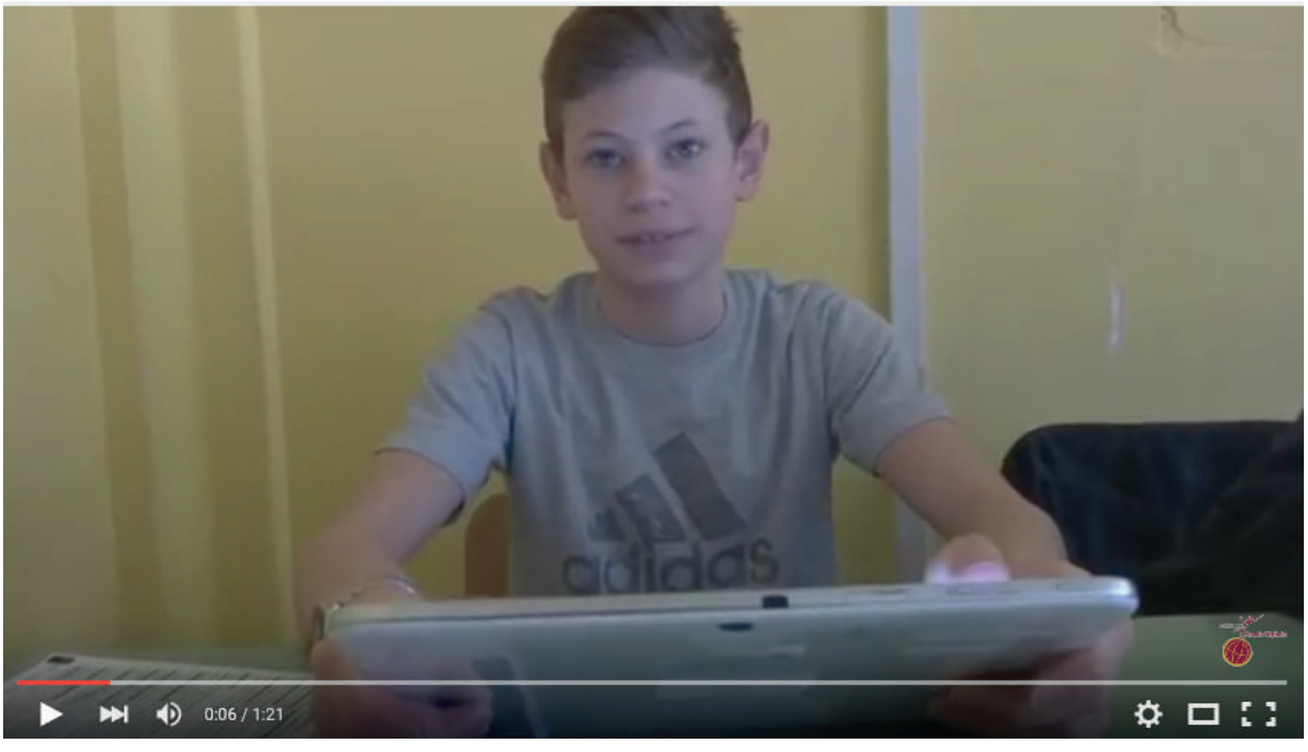

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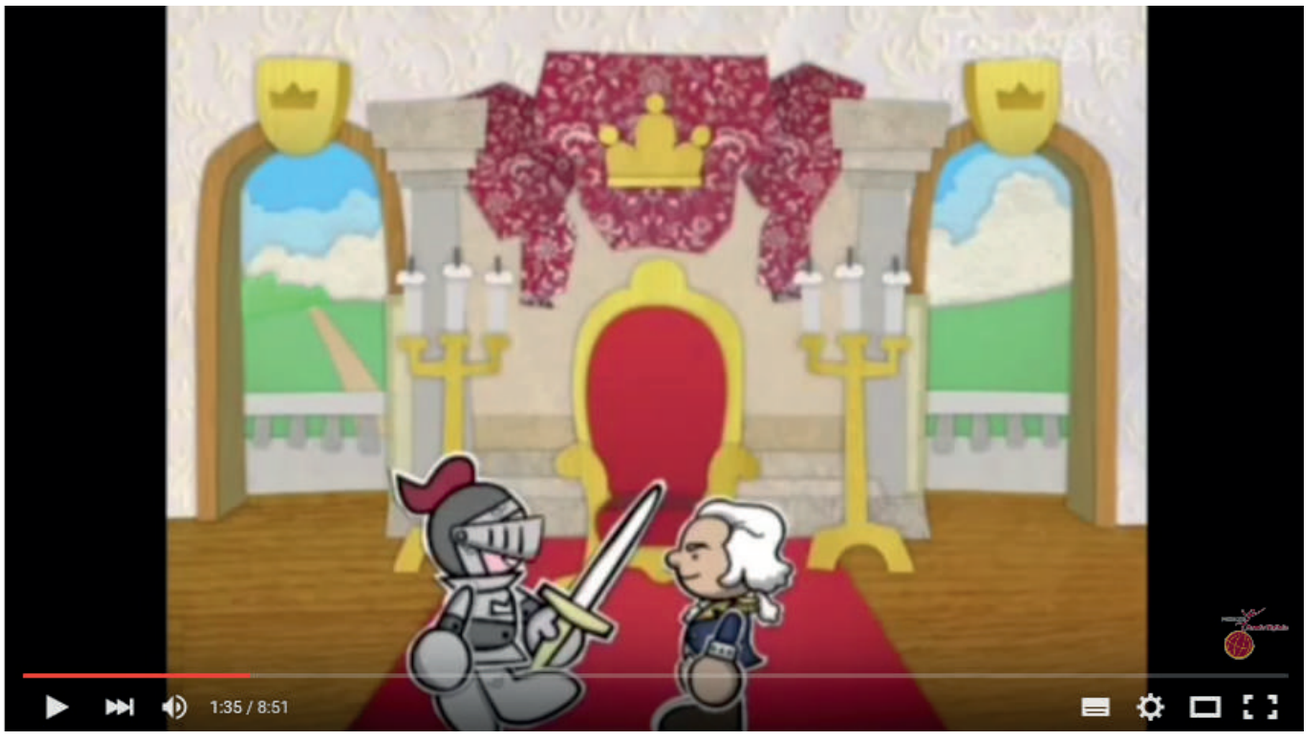
ICT supported a non-passive path to learning. As observations showed, handheld technologies were used during the pilots as tools to promote students' active and independent construction of the learning process.[15] Teachers' tutoring role exhorted students to engage in researching information, developing content and actively learning rather than passively receiving information. This instructional scaffolding process enhanced students' ability to think deeply and logically, and obtain and evaluate evidence in a disciplined way as the result of studying fundamental disciplines.[16]

As a teacher reported: "using tablets, students are more independent in searching for the information they are interested in … apps are easy to use and stimulate their creativity to develop new content while expanding the knowledge gained…". The process of multimedia courseware development is the systematic approach to the analysis, design, development, implementation and evaluation of learning materials. As another teacher highlighted: "students generate their own knowledge ... they develop concepts which were not previously given, elaborating the information gathered using applications, etc…".



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The opportunity to diversify the fruition and elaboration of content using application, encouraged students to experiment and be creative, innovative and resourceful, thus becoming able to solve problems in ways that draw upon a range of learning areas and disciplines.

Teachers reported that the introduction of innovative pedagogy based on collaborative work had an impressive

[15] C. C. Bonwell, J. A. Eison, *Active Learning: Creating Excitement in the Classroom,* George Washington University Press, 1991.
[16] S. Paavola, L. Lipponen, K. Hakkarainen, *Models of Innovative Knowledge Communities and Three Metaphors of Learning*, Review of Educational Research, 2004.

impact on the students' capacity to study independently, organising tasks and effectively managing time to complete an assignment. Furthermore, also less talkative or participative students showed diverse collaborative attitudes and the ability to take initiative and communicate ideas.

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As a teacher pointed out: "using tablets the student can be more active in collecting, processing and constructing information … students seem more actively responsible for their learning path...". As an interviewed parent pointed out: "when the lesson in class is more inquiry-based … he clearly gains more problem-solving skills and reaches deeper understanding of the subject than when the lesson is organised traditionally…".

ICT had an impact on a variety of skills and key competencies, ranging from digital literacy (defined as being able to access, integrate and create information through the use of technologies), particularly for those students from less wealthy background, who are likely to have limited access to ICT at home, to key transversal soft skills that help students to build a comprehensive understanding of the world[17] and positively impact school curriculum proficiency such as:

- Creativity
- Critical thinking
- Problem solving
- Collaboration and teamwork
- Leadership
- Organisation
- Communication

[17] C. Bereiter, *Education and mind in the knowledge age*. Hillsdale, 2002

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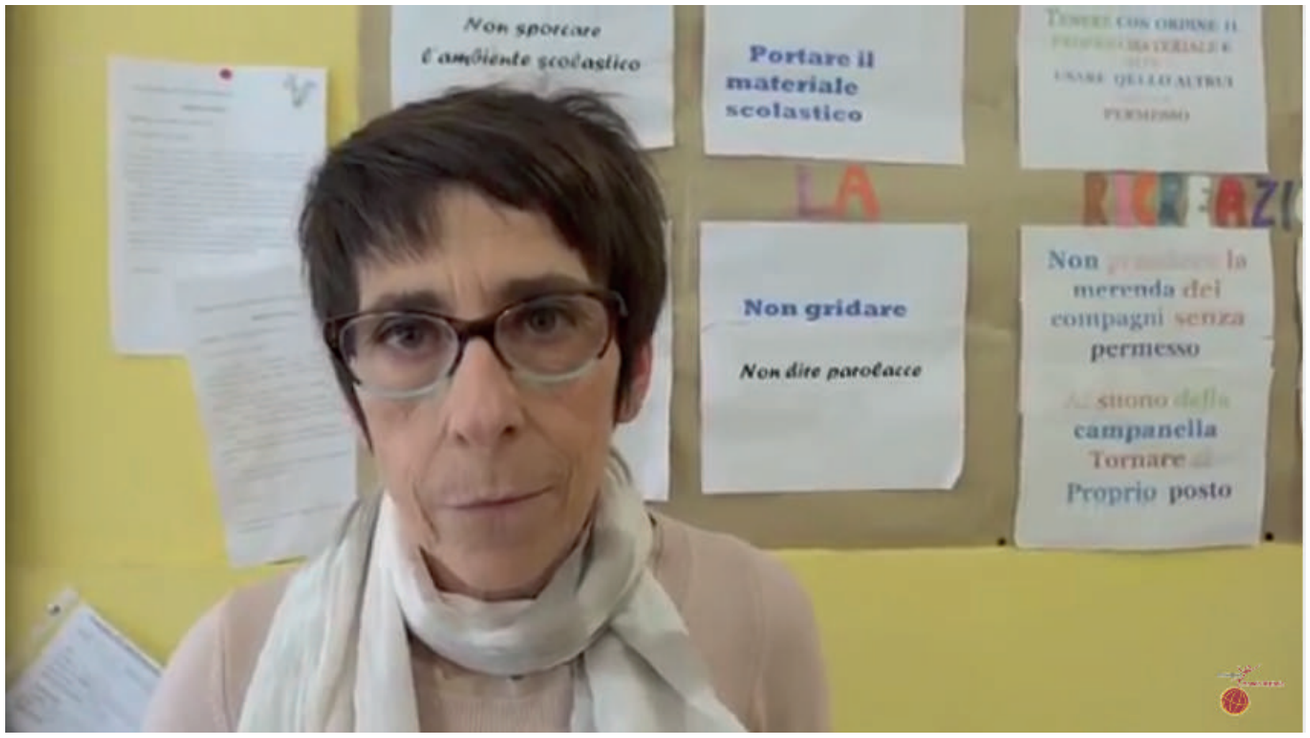
As a teacher said: "handheld technologies allow different didactic activities that require students to exercise autonomous-thinking skills … creatively…".
The use of handheld technologies increased academic standards though the provision of a wider range of resources and more engaging leaning experiences. Proficient learning resulted from the combination and application of those different skills that change the students' knowledge approach, deepen the learning experience, and teach them to assess information, thus personalising the meaning of acquired knowledge[18] through remembering, understanding, applying, analysing, evaluating and creating.
An example is the creation of videos, which enhances students' reflexion ability and opens new a perspective for their scientific understanding, inasmuch as pupils need to think what they want to record in order to explain a concept, thinking critically to re-elaborate information creatively. This enquiry-based teaching required pupils to decide which problems to investigate, how to investigate them, to search for alternative solutions, to research and collect data from different sources, as well as to elaborate content using images, text, sounds while combining ideas. As a result, the whole process is able to make students' knowledge of the subject much more thorough.

[18] L.W. Anderson, D.R. Krathwohl, P.W Airasian, K.A. Cruikshank, R.E. Mayer, P.R. Pintrich, J. Raths, M.C. Wittrock, *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*, Longman, 2001.

Impact on teachers' attitude and professional development

For most of the teachers, the motivation behind their involvement in the project consisted in the wish to enhance their professional skills, find innovative methodologies and renew personal motivation to experiment in their profession. The reluctance of teachers to embed new technologies in their teaching practice and the difficulties encountered in convincing their colleagues and head teachers of the potential benefits of the introduction of ICT in school, were mainly due to lack of technical skills. As a teacher pointed out: "I think that they are afraid because they don't have technical skills and they would be uncomfortable because students might know more about technology than they do…".

Most of the teachers had never taken part in professional ICT training before joining the project, some of them did not have advanced ICT skills. 16 hours of handheld technology technical training were sufficient to familiarize teachers with technology, motivating them to pilot the potential for learning and teaching, but not sufficient to make them feel fully confident to integrate technology in their teaching.
As a teacher pointed out: "I did not have a clear idea of how many things I could do during my lessons using a tablet and I was not expecting to become able to use it so soon...".
As a result of the initial training programme, teachers acquired digital skills, defined as abilities to manage knowledge retrieving and organizing, to deal with information for solving problems, to communicate and exchange knowledge to collaborate, and to construct knowledge products to give presentation.[19]



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[19] N. Law, Y. Lee, A. Chow, *Practice characteristics that lead to 21st century learning Outcomes*, Journal of Computer-Assisted Learning, 2002.

However, ICT skills were not the main factors for the lack of usage, as many of the teachers adopting them had no better ICT skills than other teachers in the same school.

The insights into the pedagogical role of ICT largely influenced teachers' trust in the potential role of handheld technologies in education, complemented by the ability to integrate and critically evaluate the effects of the introduction of handheld technologies in the revolution of teaching and learning practice.

Some subjects had a stronger correspondence with ICT. For instance, it was easier for teachers to discover the practical application of handheld technologies in subjects like English, Music or Mathematics.[20] Other subjects required more practice in order to consolidate the potential changes in pedagogy, triggered by the mainstreaming of technologies into educational practices.

A further 16 hours of training, including practical workshops, were required by the teachers in order to convert the potential shifts of pedagogy produced by the introduction of handheld technologies into practices. Peer tutoring and collaborative work revealed to be the most effective way to produce this change. As a teacher declared: "even when you know how to use different applications…the most difficult thing has been to imagine how to plan and deliver a lesson with your students using tablets in the classroom context…". The educator-centred vision of teaching came out refreshed by progressive inquiry, collaborative learning, and the aim of enabling students to actively engage in the knowledge-construction process.[21]

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[20] P. John, R. Sutherland, *Affordance, opportunity and the pedagogical implications of ICT*, Educational Review, 2005.

[21] D Moseley, S. Higgins, R. Bramald, F. Hardman, J.Miller, M. Mroz, *Ways forward with ICT: Effective pedagogy using information and communications technology for literacy and numeracy in primary schools*, Newcastle University and Durham University, CEM Centre, 1999.

As a teacher said: "the relationship between the pedagogical potentials and the practice of the methodology is a big issue … even when you become aware of the importance and potentials behind the use of your tablet…".
Where technical skills were not sufficient to build up enough confidence for teachers to start using ICT in classes, the practical experimentation and the exchange of knowledge with peers have nevertheless strengthened teachers' self-esteem, persuading them to start piloting in classes. Teachers acknowledged problems related to the scholastic system, the way their work is organized, the curriculum, the socio-spatial structure of work based on self-sufficient teacher-centred classes, pedagogical infrastructure not allowing teachers to organize innovative learning processes.[22]
Communication and cooperation, among teachers of different schools involved in the piloting, played a fundamental role in giving them a sense of belonging to a network of shared knowledge that was going to change teaching practices. As a teacher said: "when you try something different you can feel relatively isolated … the exchange of ideas with colleagues was so important…".
Many teachers declared that they felt ICT helped them to regain motivation in teaching, self-confidence, and professional self-esteem. Although there is evidence that ICT does not automatically make teaching less time-consuming, it is clear for interviewed teachers that this was compensated by renewed passion. Many teachers also specify that their enthusiasm increased when they saw their pupils' motivation increasing through ICT.
Knowledge sharing activated a fundamental transformation of teaching practice during the pilot project,[23] as it led to knowledge creation and knowledge sharing based on individual practice and theoretical understanding[24] on how to introduce handheld technologies within mainstream education, thus completely changing their role as teachers.
Teachers shared values and visions focusing on change in teaching to the benefit of students' learning. A meaningful pedagogical impact was consolidated by transforming classes into learner-centred collaborative communities. Many teachers indicated that their motivation increased when they saw the pupils' motivation and proficiency increasing through ICT. As a teachers said: "I was afraid but discussing with colleagues, I had an idea about how to actually do it … and when I started introducing tablets in classroom, students were enthusiastic … after few months I started noticing improvements in their proficiency and some changes in the attainment and behaviour of students with weaker commitment to studying…".

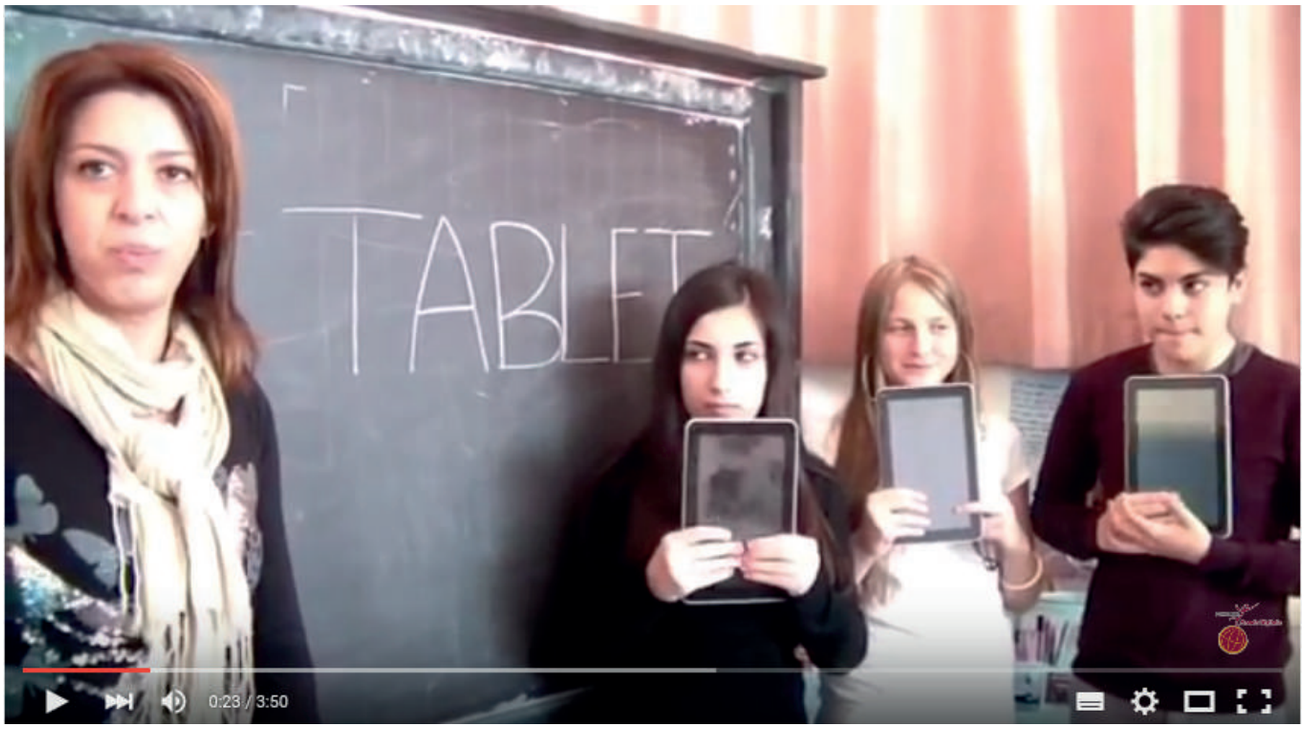
[22] M. Lakkala, J. Lallimo, K. Hakkarainen, *Teachers' pedagogical designs for technology-supported collective inquiry: A national case study*, Computers & Education, 2005.
[23] M. Fullan, *The new meaning of educational change,* RoutledgeFalmer 3rd ed., 2001b.
[24] D. Galanouli, C. Murphy, J. Gardner, *Teachers' perceptions of the effectiveness of ICT-competence training*, Computers and Education, 2004.

Benefits in special needs education

In Italy, mainstream policies dictate that students with special needs (SEN), ranging from physical, sensory, communication or cognitive disabilities in both learning and broader social opportunities, are taught in the mainstream school environments as far as possible to prevent social marginalisation.

Special needs students have the right to teaching adapted to their requisites and needs. SEN pupils are supported by professionals in charge of the development of their individualised educational plans (called PEI - Piano Educativo Individualizzato).

The experience suggests that an inclusive education model has a positive impact for all learners. Special needs students can benefit from mainstream school education if the curriculum is flexible, the teaching methodology allows for individualisation and diversification, attention is given to improving of their communication skills and the environment is positively sensitive to differences, creating opportunities for integration within the class.



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Personalised learning necessitates attention to the distinctive needs of all students of all abilities, recognising that everyone has different learning styles including students with mild, moderate or severe disabilities. The use of technology in education plays a key role by facilitating flexible curriculum development and supporting students with special needs to participate as equals in the learning experience.[25]

As the MLEARN experience showed, ICT for didactic use in the classes encouraged an innovative vision of mainstream transforming learning approaches. ICT application carries a variety of new teaching and assessment strategies for students with different educational needs.

[25] UNESCO IITE, *Information and Communication Technology in Special* Education. Analytical Survey, UNEASCO, 2001.

The introduction of mobile devices allows the customisation of the learning path and materials, for teaching students with specific learning needs and/or specific emotional or behavioural disorders, but also with difficulties arising from the lack of language abilities or communication difficulties.

Learner-centred pedagogy resulting from the usage of handheld technologies in classes enabled greater learner autonomy and expanded independent access for students to education.[26] Thanks to its flexibility and manageability the tablet facilitates students with special educational needs to accomplish tasks working from home.

Introducing the use of tablets in class, the organisation and setting changed, with students working in groups and the role of the teacher flipped from knowledge dispenser to facilitator of students' own process of knowledge creation, enhancing their self-esteem, responsibility and engagement in learning. This allowed teachers to devote more time in the classroom to support students with special educational needs, and tailoring tasks to suit individual skills and abilities.

L. Vaccari - Roma

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In MLEARN classes, cooperative learning enabled peer-to-peer learning. Working closely and sharing responsibilities to accomplish a common result, students overcame communication barriers, facilitating the integration in the class group of students who usually demonstrated less participation because of their special needs.[27]

As a teacher said: "I have organised students in working groups, providing 1 tablet for each group ... I have noticed how the use of ICT enables students to overcome barriers to learning and develop positive relationships with peers and teachers.... I was surprised to see how students who were less integrated in the class because of their

[26] D. Moore, J. Taylor, *Interactive Multimedia Systems for Students with Autism*, Journal of Educational Media, 2000.

[27] A. Lewis, M. Ogilvie, *The Impact on Users of the National Grid for Learning*, University of Birmingham, Online: http://www.becta.org.uk/page_documents/teaching/sencoforum1.Pdf , 2002.

special needs or language gaps were actively taking part in the tasks assigned, learning cooperatively...".

The use of new technologies as tools for technical assistance allowed students with special needs to take active part in the process of interaction and communication: a pupil with motor disability found a support to write, or to read in case of visual deficiency. In these terms, ICT advanced the students' ability to manage their environment, make decisions about their experiences, apply problem-solving techniques, access information, and communicate with others. We can say technology can retrieve those natural functions, supporting different ways to practice them.

Personalised learning and process-based learning enabled students to demonstrate achievement in ways, which were not possible through traditional methods, enabling the emergence of each learner's natural potentials. This also unlocked hidden potentials for those with communication difficulties and supported students with profound and multiple learning difficulties to interact and participate more easily.[28]

Technologies mediated communication with people with disabilities. As observed by a teacher: "the tablet can become a resource that eases and makes communication possible for pupils with communicative disorders to exhibit his/her abilities … it offers more opportunities to students with special needs to find their own convenient way to express themselves…".

As another teacher noted: "it is easier for students with special needs to communicate while working with peers using a tablet … it seems it is, for them, a means to relate with others…".

The extensive use of iconic type resources, typical of tablet apps, promoted learning through the use of visual memory, facilitating visually impaired students who, by using the internet, could access information alongside their sighted peers.[29]

As a teacher reported: "using tablets, students develop their own materials reflecting on the lesson learnt … while I can use it to develop tailored materials for students with special needs, making use of pictures, colours and sounds that act as means to retrieve information for those students with difficulties in understanding or retaining information, lack of attention or memory issues...".

[28] T. Detheridge, *Bridging the Communication Gap for Pupils with Profound and Multiple Learning Difficulties*, British Journal of Special Education, 1997.

[29] L. Waddell, *The Pilot Internet Project: Evaluation Report*, Royal National Institute for the Blind, 2000.

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Where strategies of collaborative learning were activated, assessment was also based on the student's implementation of real tasks. Alternative answers were accepted, thus recognizing that more than one answer was possible. In the case of special needs students, this allowed to use evaluation to demonstrate growth rather than an optimum performance of skills at the first attempt.

As a parent said: "when students work together using a tablet, they interchange dialogue, generate ideas, formulate and experiment with opinions... Each student contributes with his/her abilities... an excellent model to include students with SEN into the group!".

Impact on school

It is recognised that something changes positively when ICT is introduced in schools, but the content, direction and depth of this change depends on each school's development, improvement, innovation.[30]

In the case of MLEARN schools, the change was a bottom-up process arising from the teachers' desire to improve their professional skills and renew their teaching practice, finding renewed enthusiasm and solutions to more actively engage their students. Teachers' commitment was the power that activated a progressive change in attitudes towards the use of ICT in the schools involved in the MLEARN project.

The availability and access to ICT, internet adequate connectivity and technical support are undoubtedly prerequisites for triggering the innovation process driven by the introduction of ICT in schools. In any case, the development of teachers' ICT skills was the key element allowing meaningful introduction of handheld technologies in MLEARN schools. Teachers' ICT competences allowed the experimentation to be, not just a single step, but an ongoing process towards the embedment of M-learning in mainstream education.

As a head teacher said: "I was not expecting handheld technologies to be used in everyday multidisciplinary teaching…".

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[30] S. Bayraktar, *A Meta-analysis of the Effectiveness of Computer-Assisted Instruction in Science Education*, Journal of Research on Technology in Education, 2000-2001.
W. Korte, T. Hüsing, *Benchmarking Access and Use of ICT in European Schools 2006: Results from Head Teacher and A Classroom Teacher Surveys in 27 European Countries.* eLearning Papers, http://www.elearningeuropa.info/files/media/media11563.pdf, 2007.
R.B. Kozma, *Technology, Innovation and Educational Change: A Global Pespective,* International Society for Technology in Education, 2003a.

Teachers acquired confidence in the use of ICT throughout the training, and they developed thorough understanding of the potential of the technologies to change pedagogy. This allowed a long-term continued innovation process, in which a new pedagogy is established as part of the regular practice within the classroom and the school.[31]

Identical usages of ICT in school may have different impacts. The concrete contribution to educational change in the case of MLEARN schools was based on the development of new methods of teaching and learning, as well as on significant progress in collaboration between school staff members, thus enhancing the whole school's approach to change in the traditional education strategy.

After few months, pilot projects' evidence indicated that ICT can be used to enable activities that could not have been done otherwise or to facilitate tasks that would have been much more difficult without. The enhanced motivation of teachers added additional leverage, attracting the interest of other teachers, parents, students and the school leadership. As a teacher said: " I was afraid to feel isolated when the project started … then more and more teachers showed interest and curiosity for the experimentation and asked me to teach them how to use the tablet for teaching…". Evidence of positive experimentation in classes gradually changed the whole learning and teaching climate of the school as almost all teachers became involved with new technologies. Teachers taught other teachers, tablets were borrowed from one class to the other, multidisciplinary assignments were given to students, while the cooperation and dialogue among teachers grew regarding possible strategies to integrate tablets into pedagogy.[32]

Reinforced teacher commitment acted as a catalyst, giving rise to positive pressure for change, hence orienting the school leadership to support a potential shift.[33] Besides the general perception of the school as an innovative model by parents and generally from observers outside the school, the whole school environment treasured the

[31] M. Fullan, *Leading in a Culture of Change*. Jossey-Bass, 2001a.

[32] O. Erstad, *Integrating institutional and educational practices – Norwegian experiences on ICT and teacher professional development,* University of Oslo, 2007.

[33] A. Harris, *Effective leadership in schools facing challenging contexts*, School Leadership and Management, 2002a.

idea to make use of ICT in the mainstream education, producing a strong impact on the sustainability and replicability of the MLEARN initiative.[34]
As a teacher said: "parents and the school leadership become sensitive to prioritizing ICT teachers' training in the school agenda, funding for equipment and improvements of the internet connectivity".

The pilot project engendered a pedagogical shift. ICT skills were taught in a context integrated into the curriculum and as part of transversal skills such as information handling, collaboration and communication, and were embedded in teaching and learning practices.[35] Learning projects became student-centred. While examining and changing their own teaching practices,[36] teachers introduced students to inquiry-based learning, helping students to build a comprehensive understanding of the world through the learning path.[37] Flipped classrooms enhanced students' engagement in developing their own knowledge building.

The school leadership's support to the vision and aims of the learning and teaching enhancements associated with ICT, stimulated the shift in pedagogical approach at the school community level. This enhanced the piloting to a forward-looking plan, making a step forward in the innovation process[38] at the school level.

[34] R. Nachmias, D. Mioduser, A. Cohen, D.Tubin, A. Forkosh-Baruch, *Factors involved in the implementation of pedagogical innovations using technology*, Education and Information Technologies, 2004.
[35] J. Voogt, H. *Pelgrum, ICT and curriculum change*, Human Technology, 2005.
[36] A. Harris, *School improvement. What's in it for schools?* RoutledgeFalmer, London, 2002b.
[37] C. Bereiter, *Education and mind in the knowledge age*, Erlbaum, 2002.
[38] C. Granger, M. Morbey, H. Lotherington, R. Owston, H. Wideman, *Factors contributing to teachers' successful implementation of IT*, Journal of Computer Assisted Learning, 2002.

Conclusions

The MLEARN project's aim to develop an initial and in-service training programme for teachers on the use of handheld technologies for teaching and learning was implemented in 10 schools of different levels in the City of Rome, providing equipment and technical support to introduce the devices in the mainstream curriculum. Monitoring and evaluation of the pilot project through interviews and focus groups with teachers, head teachers, parents and students, as well as direct observation of the activities in classes, revealed the impact of the 30-month intervention, emphasizing possible recommendations for the replication of best practices in similar contexts.

Given the preconditions of adequate technical support, adequate internet connectivity and equipment of the classes in the ratio of at least 1 device every 4-5 students, in addition to interactive whiteboards or projectors for contents sharing, teacher training resulted as the key element for a meaningful embedment of handheld technologies for learning and teaching.

Teachers' ICT skills related to the functions of the device accompanied by practical activities on the functions of the different applications, gave teachers an understanding of the opportunities offered by ICT and the confidence to introduce the devices in daily pedagogy, examining and changing their own teaching practices.

The experimentation in classes allowed teachers to discover and explore innovative pedagogy, shifting towards a student-centred approach where research and re-elaboration of content helped students to build a comprehensive understanding of the world and to become responsible for their learning path.[39]

The different organisation of the class, the opportunity to tailor teaching based on students' specific needs, evidenced improvements in pupils learning, helping them develop better reasoning strategies, developing their confidence in their ability to communicate, work in teams and organise their tasks, helping them to achieve more autonomy in their learning and relate it to a wider context, hence supporting them to develop critical thinking and problem-solving skills.

The project's experience showed that these benefits were dependent on how the teacher selected and organised the ICT resources, and how this use was integrated into other activities in the classroom and beyond.

Such a commitment, together with the development of an overall school approach, where innovative teachers were not isolated, but involved in a collaborative knowledge-sharing learning community, committed to the vision of changing traditional learning and teaching practices, stimulated positive pressure for innovation as a key element for continuous growth for both teachers and schools.

Whenever the bottom-up shift in pedagogy was accompanied by support from the school board and parents, successful ICT implementation was able to achieve school innovation processes, in a replicable and sustainable way.

[39] C. Bereiter, *Education and mind in the bknowledge age,* Erlbau, 2002.

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Notes


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