ICT in STEM Education - Impacts and Challenges

SETTING THE SCENE

A STEM Alliance Literature Review

November 2016
European Schoolnet (www.europeanschoolnet.org) is a network of 31 Ministries of Education from across the European member states, leading educational innovation at European level. As a major international think tank, European Schoolnet operates key European services in education on behalf of the European Commission, member Ministries of Education and industry partners.

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- **Policy, research and innovation**: information sharing and evidence building.
- **Schools services**: enhancing cooperation between schools across Europe.
- **Advocacy**: how ICT and digital media contribute to transforming teaching and learning processes.

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EXECUTIVE SUMMARY

Due to the fast developments in Information and Communication Technologies (ICT), many young people are constantly connected to digital devices and the Internet. This has changed the way they receive and process information, and the education system is slowly starting to adjust and explore the opportunities that ICT can bring for students’ learning and development.

In this report we set the scene on how Science, Technology, Engineering and Mathematics (STEM) education can improve students’ learning outcomes and skills development with the help of ICT, and how business can support education in these developments. This is an important topic because, at present, around 40% of European employers say they face difficulties in finding the right people with the right qualifications (EU Skills Agenda, 2016). Yet, at the same time, education providers are twice as likely as young people or employers to consider recent graduates adequately prepared for the labour market. Already the demand for digital and high-end skills exceeds supply, a gap which is expected to grow further in the future. Furthermore, 70 million Europeans lack basic skills, increasing their risk of unemployment and social exclusion. Using ICT in education can thus provide significant benefits for education, youth and employers.

This research is based on a literature review carried out in 2016. We provide several answers to the following broad question:

- What are the impacts and challenges of ICT in STEM education?

The extensive literature review that provides the background information for this report ranges mainly from the beginning of the 21st century to date. This report will be followed up by three more that will go in-depth into the impacts and challenges of ICT in STEM education on 1) students, 2) teachers and 3) other stakeholders such as schools as a whole or the private sector.

To set the scene, we first review separately the teaching and learning of STEM subjects and the developments of ICT tools. Then we consider the integration of technology into STEM education. There is a growing consensus that progress in the integration of technology and education should be guided by research evidence, and we include a final section which briefly discusses research questions and methodologies.

The main results found from the literature review are as follows:
The different “tempos”, inertias and paths of ICT and STEM innovation pose a challenge to all stakeholders involved when trying to develop STEM curricula that integrate technology.

ICT can reinforce the student skills that STEM education is supposed to develop, like problem-solving, logical and critical thinking, and technological literacy.

In view of the increasing amount of information available nowadays and more ways to consume it, such as BYOD (Bring Your Own Device) and Cloud computing, schools must be equipped with the infrastructure to support current digital devices (high speed Wi-Fi and stations for charging devices).

Decisions (as well as monitoring and assessment) on ICT and STEM integration should be based on researched evidence. This research must meet the standards of Education Research.

Business-Education collaboration can increase the uptake and effectiveness of ICT in STEM education by aligning curricular development with skills needs for employment; ensuring that the material and information remains up to date; and providing real-world contextualisation and training for teachers.

Additionally, further findings, recommendations and challenges include:

The school ecosystem is changing greatly with the introduction of technology, and this change can have significant benefits but also poses certain risks.

Potential benefits
In particular, STEM education should give students the opportunity to practise all sorts of skills acquired in science classes or projects such as: observing, experimenting, planning, evaluation skills, problem-solving skills, abstraction skills, logical thinking skills, etc. ICT tools can be used to enhance conceptual understanding and promote higher-order thinking skills among students. Furthermore, STEM Teaching and Learning may benefit from various holistic approaches to transforming education that have been suggested by public and private stakeholders.

Key challenges
The digital skill set developed by the so-called “digital natives” in informal ways is usually incomplete and has to be enhanced and refined by the school: “The skills that young people develop by themselves with regard to technology do not necessarily help them to maximise their learning opportunities” (OECD, 2012). Important issues at stake are individual differences and needs and the range of skills required to benefit from an educational use of technology. The possible requirement (for students and teachers) to obtain a certification of basic digital skills that may serve as a starting point for skills improvement is not sufficiently widespread. In fact, the digital divide (in terms of use) also exists within the boundaries of developed countries.

Skills
Technology allows many applications in the classrooms, including teamwork. Furthermore, the recent emergence of “big data” tools will certainly affect education as ICT can provide the means of storing and analysing a wide range of data on the progress of (individual) pupils, classes and schools over time. The use of specific ICT tools in the STEM ecosystem can be designed to support models of teaching and learning that incorporate real-world applications, and include research, design, analysis, composition and communication. Successful STEM implementation requires an alignment of curriculum, learning resources, technology, teaching and management to address all students.
The importance of teachers

The importance of the teacher in ICT integration cannot be overstated. Teachers need to extract up-to-date contents from a variety of ICT sources, not only from printed textbooks, but they need time to develop effective pedagogy around ICT, which involves significant efforts in terms of planning, preparation and follow-up of lessons.

Research

Research on the integration of ICT into STEM Teaching & Learning is increasingly mature and robust. Research should address the questions that educational leaders, teachers, schools and policymakers care about, exploring the effects and impact of ICT implementation, in addition to better understanding how to use it. Indeed, in-depth studies of ICT in STEM education in schools from different countries evidence a measure of robustness in the findings, which would make them of use in any other country. Still, efficient research strategies are needed to make the best use of the resources that are becoming available at an increasingly rapid pace and to incentivise transfer of existing education research into the classroom in order to inform teachers’ practice. One example is the development of research-validated, standardised sets of surveys that allow comparisons of ICT+STEM education both locally and internationally.

Stakeholders

All stakeholders must work in concert to establish an inclusive ICT+STEM ecosystem that encourages better uptake and use of digital services, and to make sure (via monitoring and assessing) that new pedagogies supported by ICT are effectively embedded in practice. Specifically, European employers (and intermediaries) should have an active role to help ensure that ICT in STEM education is up to date, in line with skills needs within the workforce, and provides added value for students, teachers, business and society at large.

Overall

The topic of ICT support to student education in STEM is more alive than ever and with many exciting new developments and opportunities available which provide challenges for research and classroom action. In general, continuous investigation and action research is needed to make sure that ICT is deployed in the best of pedagogical ways and fulfils the expectations of all stakeholders involved. And for this to happen, organisations and initiatives like the STEM Alliance (or similar bodies at national level) need to communicate the results of research effectively and meaningfully to the various target audiences, including policymakers and teachers.

“Because IT [information technology] changes the way we interact with the world, IT changes us”

Prof. Jonathan Anderson, School of Education, Flinders University, Australia.
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ABBREVIATIONS

In Table 1 we show the main abbreviations used in this publication.

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<thead>
<tr>
<th>Abbreviation</th>
<th>Meaning</th>
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<tbody>
<tr>
<td>ER</td>
<td>Education Research: Science (SER), Physics (PER), Chemistry (QER), Maths (MER), Engineering (EER), Biology (BER), etc.</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
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<td>EUN</td>
<td>European Schoolnet</td>
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<tr>
<td>ICT</td>
<td>Information and Communication Technologies</td>
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<tr>
<td>IoT</td>
<td>Internet of Things</td>
</tr>
<tr>
<td>STEM</td>
<td>Science, Technology, Engineering and Mathematics</td>
</tr>
<tr>
<td>T&amp;L</td>
<td>Teaching and Learning</td>
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The STEM Alliance – inGenious Education and industry – brings together industries, Ministries of Education and education stakeholders to promote STEM education and careers among young Europeans and addresses skills gaps within the European Union. The STEM Alliance builds on the success of the inGenious initiative (2011-2014)1 to increase the links between STEM education and careers, by involving schools throughout Europe. With the support of major industries and private partners (see back cover of this publication), the STEM Alliance activities promote STEM jobs in all industry sectors and contribute to build a STEM-skilled workforce. The STEM Alliance aims to improve and promote existing industry-education STEM initiatives (at national, European and global levels) and contribute to innovation in STEM teaching at all levels of education. The initiative is coordinated by European Schoolnet and CSR Europe, and more information can be found at: http://www.stemalliance.eu/

As a contribution to the challenge of integrating ICT tools in STEM education and improving students’ learning and attitudes towards STEM subjects and careers, the STEM Alliance has initiated a series of literature review reports and special issues that address the following key question:

What are the impacts and challenges of ICT in STEM teaching and learning, from the viewpoint of the stakeholders involved?

The reports will be based on a broad literature review that covers a number of aspects of recent relevance in the field of ICT in STEM education. In particular, all the reports will:

- Analyse the potential and the role of ICT in STEM teaching and learning processes.
- Analyse how ICT is used in STEM education, and the impacts on pupils’ motivation and understanding for STEM topics.
- Analyse why the use of ICT in STEM education can stimulate interest in STEM topics and careers.

The aim is to provide suggestions and guidelines for all stakeholders interested in promoting ICT in STEM education at both primary and secondary school level.

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1 inGenious was the European Coordinating Body in Science, Technology, Engineering and Mathematics (STEM) Education, a joint initiative of European Schoolnet and the European Roundtable of Industrialists (ERT) aiming to reinforce young Europeans’ interest in science education and careers. With a grant of €8 million from the European Commission’s 7th Framework Programme over a three-year period, and the support of 42 partners from 20 countries, including seven major industries, inGenious was one of the largest and most strategic projects in science education undertaken in Europe.
Series scope

The extensive literature review that provides the background information for this series of reports has the following boundaries and caveats:

- **Scope.** Each report of the series focuses on a specific topic, context and challenges. Specifically: setting the scene (the present report), students, teachers and other stakeholders (future reports).
- **Dates.** Most literature review is from the 21st century (from 2005 onwards except for one case).
- **Level.** Primary & Secondary Education (from 4 to 21 years old).
- **Overlap.** Inevitable overlap among reports in this series will be kept to a minimum.

Series contributions

In this report we provide general considerations that relate to all three collectives taken together: students, teachers and other stakeholders, which serve to set the scene. We consider the characteristics of STEM teaching and learning, as well as the evolution of ICT tools, and then we look into the integration of the two. The potential of research to find evidence about impacts of ICT on STEM education is also analysed.

In three subsequent reports, we will cover the impacts and challenges of ICT on students, teachers and other stakeholders respectively. In a special issue some of the most recent ICT applications that are starting to find their way into STEM education have been reviewed.

<table>
<thead>
<tr>
<th>STEM Alliance - Impacts and Challenges Series</th>
<th>Expected publication date</th>
</tr>
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<tbody>
<tr>
<td>Report-I Setting the scene</td>
<td>Nov 2016</td>
</tr>
<tr>
<td>Report-II On Students</td>
<td>Feb 2017</td>
</tr>
<tr>
<td>Report-III On Teachers</td>
<td>Apr 2017</td>
</tr>
<tr>
<td>Report-IV On Schools, Administration &amp; Private Sector</td>
<td>Jun 2017</td>
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<table>
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<tr>
<th>Special Issues Series</th>
<th>Expected publication date</th>
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<tbody>
<tr>
<td>ICT Tools for STEM Teaching and Learning (in collaboration with Microsoft).</td>
<td>Nov 2016</td>
</tr>
</tbody>
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Formatting

For ease of reference, we indicate the main results of the literature review with the following mark:

- **IMPACTS**

And the main challenges and suggestions with this mark:

**CHALLENGES**

Short texts backing up both kinds of review outcomes are provided.
1. INTRODUCTION

This report draws upon a literature review on how Science, Technology, Engineering and Mathematics (STEM) education can be improved with the help of Information and Communication Technologies (ICT). It serves to set the scene for the upcoming more specific reviews on impact on students, teachers and other stakeholders.

We shall provide some answers to the following broad question:

- What are the impacts and challenges of ICT in STEM teaching and learning?

The improvement of STEM education in society at large, as well as the persisting evidence of skills shortages issue forecast in STEM fields (Caprile et al., 2015) are major challenges in developed and developing societies that should be addressed by various means. One of the efforts is to increase pupils’ interests for STEM subjects already at primary and secondary school levels, and the extended use of ICT in STEM teaching and learning (T&L) has often been advocated as a means to engage STEM students (USA National Research Council, 2011):

“There is a continued push to develop STEM curricula that meaningfully integrate technology into as many curricular layers as possible” (USA National Research Council, 2011).

However, introducing ICT in schools is not sufficient to have a positive impact on the students. Technologies can greatly support good teaching plans, in principle, but to be sure of their impact, the students’ learning has to be investigated. Therefore, a strong framework with sound pedagogical processes, strong collaboration with key stakeholders and appropriate teacher training is necessary to ensure a positive uptake of ICT in STEM education. This poses a challenge but also opportunities for all stakeholders involved, including students and teachers, supported by schools, parents, administration and the private educational and ICT sector in various forms (see Figure 1).
In the STEM Alliance ICT in STEM education series, we outline the state of the use of ICT in STEM education in Europe and elsewhere through a literature review, looking at the various opportunities technology offers for both teachers and schools and how it impacts on the pupils. We investigate whether through the use of ICT (Web-based tools and applications, devices, learning and teaching equipment, mobile delivery devices and content delivery methods) one finds an increase in student motivation, self-confidence and self-esteem, in addition to the attainment of academic objectives (report planned to come out in February 2017). Teachers’ attitudes towards technology will also be considered, as they are inevitably reflected in their pupils’ attitudes (expected to be published in April 2017).

This information will be valuable for education leaders to inform stakeholders and users of ICT in STEM education concisely about the complex issues involved, and possible ways to improve STEM education in our societies at large. So, we attempt to provide answers to the previous question, which we may specify further:

- What are the best strategies, the impacts and the educational consequences of introducing ICT in STEM education?

In this report, we look in general terms at the ecosystem accompanying the introduction of ICT in STEM education (from the different stakeholders, to research and society at large), helping us to set the scene for the more detailed reviews. First we briefly consider the fields of STEM education and ICT tools, separately, and then the integration of the two. Finally, we consider how research into the outcomes of ICT in STEM implementation can be performed and what kinds of questions and methodologies are used to find evidence.

As mentioned, in the next report we shall adopt the viewpoint of students, and then of teachers in the third report; the fourth report will deal with the set of possible stakeholders’ support actions for teachers and pupils.
to complement the introduction of ICT in education, including: policy, investment, teacher training, school organisation and developments, and the important support by the private sector. In all cases, we outline key priorities and successful models for scaling up STEM enrichment, enhancement activities and actions to raise interest and motivation of pupils using ICT. This will suggest steps in order to use ICT to stimulate interest in STEM topics and careers as we look at ecosystems designed around technology in the school environment, and the social and STEM skills needed to build students’ capacity at primary and secondary education levels.

**Different inertias, and “tempos”**

First we shall set the stage by considering the differing “tempos”, inertias and paths of development afforded by STEM education and by ICT tools. In an in-depth review on ICT in STEM published in 2003, Osborne and Hennessy characterised most pedagogy before that date (and, we add, nowadays) as rather conservative. As shown in Figure 2, in many cases, the teacher lectures while students listen passively. The world of education is characterised by an enormous resistance to change with mostly teacher-centred teaching or teacher-centred activities.

How common is the use of ICT in the classrooms? Across the countries and economies participating in the Teaching and Learning International Survey (TALIS),² it seems that ICT is still used less frequently than more passive teaching methods, such as working in exercise books. For example, over 70% of TALIS teachers report checking students’ exercise books frequently, while only 38% report frequently using ICT. This is surprising given the prevalence of ICT in most students’ lives across TALIS countries and economies. While some systems need to invest more in the provision of the necessary resources, there is also a need for in-depth support for teachers in almost all TALIS countries and economies. As with most methods, the effectiveness of ICT

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in advancing teaching and learning depends on the way it is used in classrooms. Hence, comprehensive professional development should be tailored to teachers’ particular needs if education systems want to harness the potential of ICT for effective teaching and learning.³

On the other hand, the world of ICT is characterised by an extremely fast turnover in software and hardware development and innovation.

Whereas STEM education progresses slowly and with many Teaching and Learning (T&L) approaches suggested that take time to be propagated even partially among teachers and schools, ICT development often overshoots the projected targets or objectives, and in a very short time.

The widely different rhythms of technology and education are evident when one compares ICT in STEM education in the intervening years since the major review mentioned above (Osborne and Hennessy, 2003): ICT has evolved and changed in some previously unimaginable ways, whereas STEM T&L has just continued with business as usual. So, rather different “tempos” or time-scales have to be contemplated in the integration of ICT in STEM education and this poses major challenges for all stakeholders involved. But if teachers and other stakeholders continue to make 20th-century decisions, many educational opportunities will be lost in what has been characterised by Katz & Golden (2008) as a race between technology and education.

In fact, it has been argued, teachers are educating students for a world that does not yet exist and is constantly and quickly being reshaped by a number of socio-political forces (Figure 3), including technology. It is claimed that “65% of today’s grade school kids will end up at jobs that haven’t been invented yet” (LeBaron & McDonough, 2009).⁴

⁴  One could go a step further and argue that schools should prepare students to deal with technological developments responsibly and critically and prepare them for the uncertain. For further reading on future jobs and 21st century skills, see Dr. Willard R. Daggett’s “Preparing Students for Their Technological Future” accessible from http://www.leadered.com/pdf/Preparing%20Students%20for%20Tech%20Future%20whitepaper.pdf or UNESCO’s “The futures of learning 2: What kind of learning for the 21st century?”, accessible via http://unesdoc.unesco.org/images/0024/002429/242996e.pdf
A few words about STEM education are in order here. Sometimes we shall refer to Science Education and not to STEM education, because Primary School Science is usually not divided into subject areas. However, unless stated, one can read indistinctly terms like Science or STEM, pupil or student.

Indeed, the subjects of science, technology, engineering and maths are integrated with a focus on world problem solving (Sanders, 2009) and as a basic ingredient of modern culture and citizenship. Specifically:

- “STEM education is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy” (Tsipros, 2009)

With one caveat: it is crucial that the “engineering and technology components are not dominated by the stronger science and mathematics subcultures” (Jones et al., 2013).

Although a traditional pedagogy is still to be found in classrooms (see Figure 2 above), new roles for the STEM teacher (guide, innovator and motivator) are invoked in modern pedagogical trends (Figure 4), which encourage constructivist T&L, and include creating a learning community and connecting science teaching with the other disciplines (Barak et al., 2011).
But, albeit important, this set of teachers’ roles is just one of six key factors (UNESCO, 2011) for a renewal of STEM education, Figure 5.

As a result of the suggested renewal of STEM education, which also includes curricular materials, STEM students are described as “problem-solving, innovators, inventors, self-reliant, logical and critical thinkers, and technologically literate” (Lantz, 2009) within a larger framework of so-called 21st century skills of collaboration and communication. So, STEM education should give students the opportunity to practise the above-mentioned skills through STEM classes (Geoffrey, 2010).

A holistic approach to transforming education is not only taken by institutions like UNESCO (2011), but also by educational departments of companies like INTEL (2006) and Microsoft (2014), among many others. Companies and other employers in fact have an important role to play in supporting educational transformation. Specifically, in helping keep schools and teachers up to date on business needs and developments; in providing a realistic context for STEM education; for supporting curriculum development and training teachers. Without interaction and dialogue between the world of education and business, the conservative education system will always fall one step behind. One problem in all agendas is how to address the outdated belief, that only especially talented students can approach STEM subjects (Marginson et al., 2013).
3. ICT TOOLS

The variety of technologies included in the abbreviation ICT is ever more encompassing and difficult to define. Many attempts are reported in the literature, including UNESCO’s (2011):

- “A diverse set of technological tools and resources used to transmit, store, create, share or exchange information.”

These technologies (mostly digital) include hardware, software applications and connectivity, and many taxonomies of ICT tools are possible: the classification of ICT products can be difficult due to the “rapidly changing character of ICT goods and services” (OECD, 2009). Furthermore,

- “There is significantly more information available to be consumed today than in past generations [and] more ways to consume it” (Devlin et al., 2013).

The different rhythms and uses of ICT in schools and society, mentioned in Section 2, become apparent when one realises that even very recent big surveys like PISA\(^5\) (OECD, 2015) of ICT in education do not specifically contemplate the use of smartphones as a T&L tool.\(^6\)

In Table 2 we display some examples of the increasing number of elements in the ICT landscape, comprising tools, devices and infrastructures. These technologies are, or may be, part of STEM education. The increasingly distributed nature of communications provides direct control over technology while enabling game-based learning, for instance, and also sharing data and files with a distributed network of peers (Israel, 2013). The list is not exhaustive and the classification is only rough. It does not include specific STEM technologies (data loggers and sensors), nor the explosive growth of Cloud-based and mobile-phone based applications, nor current ICT developments like the Internet of Things (IoT), 3D printing, Robotics, etc.

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5 PISA = Programme for International Student Assessment

6 In general, the report says: “It may […] be that online and offline entertainment activities are done with smartphones, rather than with computers.” But the questionnaires did not define the term “computer”. Also, in a section on Maths, “computers” included desktop, laptop and tablet computers, but not other ICT devices, such as smartphones.
TABLE 2: THE ICT LANDSCAPE: EXAMPLES OF TOOLS, DEVICES AND INFRASTRUCTURES

<table>
<thead>
<tr>
<th>Web-based applications</th>
<th>T&amp;L tools</th>
<th>Mobile delivery devices</th>
<th>Content delivery</th>
<th>Other devices / technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning Management Systems</td>
<td>Interactive whiteboards</td>
<td>Storage devices</td>
<td>Podcasts, Vodcasts</td>
<td>Instant messaging &amp; Social media</td>
</tr>
<tr>
<td>Quizzing &amp; Testing</td>
<td>Personal communication (e.g. email, Skype)</td>
<td>Audio Players &amp; Readers</td>
<td>Repositories</td>
<td>Video &amp; Animation</td>
</tr>
<tr>
<td>Digital Student Report Card</td>
<td>Office applications</td>
<td>(Handheld) Personal Digital Assistants</td>
<td>Blogs</td>
<td>Moblogs &amp; Photoblogs</td>
</tr>
<tr>
<td>Plagiarism Detection Systems</td>
<td>(Info)Graphics</td>
<td>Mobile phones</td>
<td>Wikis</td>
<td>Cameras, Scanners</td>
</tr>
<tr>
<td>Collaborative Workspaces</td>
<td>Screen capture &amp; casting</td>
<td>Laptops</td>
<td>Voice over Internet Protocol</td>
<td>Webinar &amp; Webmeeting</td>
</tr>
<tr>
<td>Virtual Classroom Systems</td>
<td>Website</td>
<td>Tablet PCs</td>
<td>Digital TV</td>
<td>Swarming (&quot;meetups&quot;)</td>
</tr>
<tr>
<td>e-Portfolios</td>
<td>Forms, Polling &amp; Survey</td>
<td>Gaming Devices</td>
<td>Discussion Forum &amp; Chat</td>
<td>Peer-to-peer Networking</td>
</tr>
</tbody>
</table>

The knowledge-society skills needed to handle and create information and knowledge (UNESCO, 2011) overlap greatly with those promoted by STEM education: data handling, problem-solving, critical thinking, analysis, collaboration, communication and argumentation. However, although most current pupils are so-called digital natives, “the ICT skill set that will be developed [by digital natives] in informal manners is likely to be incomplete” (Bennet et al., 2008). An interesting possibility for students and teachers is to obtain the Certification of ICT Skills (ECDL, 2011) provided by the ECDL Foundation.

Source: Adapted from Millea et al. (2005).
• “The ECDL programme, which can be easily incorporated into school curricula, develops the digital skills that are currently required to effectively operate a variety of devices and applications.”

This is one of the initiatives developed to fill a need, in the form of ICT Drivers Licences (ECDL, 2011) or similar certificates (Chisalita and Cretu, 2012; Bøgger & Gjørling, 2000) and programmes that address the important issue of digital (and STEM) skills and career development (e-Skills AT report, 2014):

• “Most of the strategies and measures […] do not relate solely to ICT, but to the STEM area in general, with ICT qualifications gaining in relevance. […] Industry associations [make] calls for action to ensure adequate supply of e-skills from ICT professionals” (e-Skills AT report, 2014).

The administration of certificates and the development of curricular materials for digital skills follow the requirements of well-defined standards (ITEA, 2007) (Figure 6), that specify the understandings that the students have to develop regarding the characteristics, core concepts and relationships of technology with other fields of study.

![STANDARDS FOR TECHNOLOGICAL LITERACY](image_url)

**FIGURE 6: STANDARDS FOR TECHNOLOGICAL LITERACY**

The use of ICT in schools has currently renewed technical requirements:

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8 The focus of ECDL is mainly operational in nature and prioritises the ability to use spreadsheets, databases, word processors, emails, and presentation software. To the best of our knowledge, ECDL is the only European organisation offering ICT certification at European level. However, other initiatives emerge at a different scale: international certifications that are widespread in Europe (e.g. IC3 by Certiport), national ones (e.g. in Poland, several certifications based on digital competence are being developed at the moment by different foundations such as Fundacja ECCC, [http://www.eccc.com.pl/](http://www.eccc.com.pl/)), and regional (e.g. Actic in Catalonia, [http://acticweb.gencat.cat/ca](http://acticweb.gencat.cat/ca)). For students in Finland: [http://blogs.helsinki.fi/ict-driving-licence/](http://blogs.helsinki.fi/ict-driving-licence/); for digital competence tests for students that can be integrated in the curricula in Austria, see [https://www.bmb.gv.at/schulen/efit21/digi_comp.html](https://www.bmb.gv.at/schulen/efit21/digi_comp.html); and for teachers and students in France: [https://c2i.enseignementsup-recherche.gouv.fr/etudiants/quest-ce-que-les-competences-numeriques](https://c2i.enseignementsup-recherche.gouv.fr/etudiants/quest-ce-que-les-competences-numeriques).
“In order for students to use technology to enhance their learning, schools must be equipped with the infrastructure to support digital devices […] this means high speed Wi-Fi and stations for charging devices, rather than projectors and interactive boards” (French, 2016).

As we shall see in Section 5, research models are developed to assess the efficacy of ICT implementation. According to Chisalita and Cretu (2012), “technological literacy emphasises knowing how hardware and software work and can be used, and digital literacy emphasises the ways in which knowledge and skills could be applied to solve specific tasks like educational activities.” One should note, however, that preconceptions about the use of technology are often wrong, and the inequitable distribution of ICT resources (the “digital divide”) may be widespread:

- “Educators sometimes think of the digital divide as a particular phenomenon of the developing world, but it also exists within the national boundaries of developed countries”. (Dix, 2007a)

Moreover, the digital divide is not only characterised by access to technology, as it was when the term emerged.9 It can be seen nowadays as increasingly depending on skills: the divide would then be between those who are able to use technologies and digital devices and those who are not (Erstad, 2010).

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9 The concept came into use in the 90s to designate the differences in digital inclusion (Irving et al., 1999).
As we discussed in the Introduction, education and technology have different inertias and “tempos”, but they also run on different time-scales. Whereas education is the current synthesis of all past society’s learning and mistakes, technology is contributing greatly to shaping both present and future. In any case, STEM education, like society at large, is inevitably immersed in the “ICT sphere”.

Indeed, the school ecosystem is immersed in several ICT spheres applying pressure from various fronts, as exemplified in Figure 7. And, in fact, “technology should be part of a school, and not just unique to a school looking to incorporate STEM” (Chiu et al., 2015).

The technological set of tools overlapping the school ecosystem from the various agents can be quite diverse. In fact, it can benefit all key stakeholders to collaborate better to ensure that pressures from different sides are turned into opportunities to work together as a smooth ecosystem. In an ideal situation this collaboration between governments, business and education can have benefits for all as outlined below:
• Young people, already at an early stage, connect with the world of work and innovation to get better equipped for the digital and inclusive society they aspire to. For this they need to be well informed and have access to information regarding:
  - All educational choices that exist
  - The myriad of possible career paths

• Teachers are supported by industry, to improve the design, delivery and evaluation of curricula for employability skills, transversal skills and global competence. In addition, exposure to industry fosters a better understanding of the world of work and the present and future risks and opportunities of the dynamic labour market.

• Employer engagement in youth education and youth employability is done in a smart and long-term way as part of the strategic and long-term business success targeted at boardroom level.

• Education is about the delivery, evaluation and certification of a smart mix of skills (basic, soft, transversal and hard skills) that helps prepare learners in their transition to jobs. As such, the success of schools (primary, secondary and tertiary) is also measured by what becomes of their graduates.

• Governments: can create effective policies that support collaboration within the STEM education ecosystem, and ensure high quality, safe and efficient education for all.

At the moment many of these stakeholders are already working on these issues together. As mentioned, within the other reports of this series we will explore these stakeholder groups in more depth.

We show in Figure 8 the structure of the four interrelated elements that make up the T&L process: design, activities, strategies, evaluation. Based on the structure of these elements, one may design specific situations where ICT (programs, simulations, spreadsheets, digital resources, science museums, automated labs, etc.) can support and complement the teachers’ and students’ work. ICT can improve students’ learning, and their attitudes and motivation towards technologies in STEM may help teachers to improve standards and encourage new ways of T&L. The technology can be designed “to support models of teaching that incorporate real-world applications, using research, design, analysis, composition, and communication” (Goddard, 2002).

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10 An example of such initiatives is the European Pact for Youth, which brings the EU and business leaders together with NGOs and experts in Europe to create a culture of collaboration in Europe on Education and Employment.
Traditionally, the purposes for which ICT is used in STEM education may be divided into four broad areas: data handling, information, communication and exploration, and each of these areas covers a range of software and hardware (see Figure 9).

The development of ICT in the form of mobile devices, such as laptop computers, tablets and smartphones, together with the development of interactive Web 2.0 and Cloud applications, can enhance both T&L even more (Barak et al., 2011). It has been reported also (EDASMO, 2009) a very good correlation between the percentage of monthly use of educational software and the time spent in active learning. On the other hand, in 2012, 96% of 15-year-old students in OECD countries reported having a computer at home, but only 72% reported using one
at school. Overall, students who use computers moderately at school tend to have somewhat better learning outcomes than students who use computers rarely. But students who use computers very frequently at school do much worse, even after accounting for social background and student demographics. (OECD, 2015).

In Figure 10 we show the many languages of STEM, including the mother tongue, which can be used to describe and analyse natural phenomena. ICT tools can help in all of them because these technologies can facilitate the construction of knowledge, the reinforcement of links (languages, descriptions), the sharing of digital information and data, and the interaction among students and with the teacher.

Anderson (2005) addresses how “trends in ICT are impacting and changing our lives and, from necessity, changing the nature of schools” brought about by the integration of ICT in T&L. Technology allows many uses of technology in classrooms, including teamwork (Goddard, 2002):

- “It is time to step away from this technology-centred focus and promote classroom learning activities in which students work in small groups rather than in isolation or as a whole class”. (Goddard, 2002)

In spite of the relatively “old” suggestion above to teamwork in classrooms fostered by ICT tools, very little research exists in this area. Furthermore, the enormous potential of ICT to personalise T&L was put forward some years ago (Becta, 2003):

- “It is becoming possible for each child to be educated in a way and at a pace which suits them, recognising that each is different, with different abilities, interests and needs.” (Becta, 2003)
Again, this expectation is still largely unfulfilled. Little research has been published on this issue, like apart from singular cases like technology uses in special education (Kirk, 2011) or recent coordinated efforts like the ‘inclusive’ STEM school project (Lynch, 2013). More research is necessary to find the best tools and strategies for implementing this goal.

At the same time technology has created new problems around issues of accessibility, safety, and accountability. Even more worrying, the digital divide (access to ICT tools and information) is giving way to a ‘second’ divide, having to do with the “ability to search, interpret, deal with, produce and disseminate understanding and especially to be able to use technology confidently, in a creative way” (UNESCO, 2009). These problems will be dealt with in another report in this series.

Schools have yet to take advantage of the potential of technology in the classroom to tackle the digital divide and give every student the skills they need in today’s connected world, according to the first OECD PISA assessment of digital skills (OECD, 2015, Students, Computers and Learning Making the Connection).

The report found that the gap between advantaged and disadvantaged students in digital reading was very similar to the differences in performance in the traditional PISA reading test, despite the vast majority of students using computers whatever their background. This suggests that to reduce inequalities in digital skills, countries need to improve equity in education first.

Three opposed paradigms are discussed by Aviram & Tami (2004) on the impact of ICT on education, Figure 11, relating to the perceived relative influence of technology on educational practice: just a toolset, just one more motivation for improvement, or an occasion for a new holistic approach.

There is a big concern regarding Internet safety and the responsible use of ICT by children and teachers. A number of initiatives already tackle the issue at least regarding to Internet: e.g. Better Internet for Kids (https://www.betterinternetforkids.eu/web/portal/about) helps make sure children are aware of risks on the Internet (what to post on social media/privacy/security issues) and how to find/decide what is relevant and reliable information.
The study by Minnigerode and Reynolds (2013) quotes, among the principles for successful STEM implementation, to “align curriculum, learning resources, technology, teaching, and management to help all students meet or exceed the standards”. The importance of the teacher is always underlined (INTEL, 2014):

- “Mobile devices, new data sources, and instant feedback mechanisms can empower students and teachers with powerful capabilities, but their use must be guided by highly qualified teachers.” (INTEL, 2014).

ICT can improve standards and encourage new ways of T&L. For instance, science subjects are usually kept orthogonal among themselves in the curriculum, but ICT and modern science practice tends to integrate them. ICT tools have been shown to contribute to STEM curricular objectives (Barak, 2014):

- “[ICT tools can be used] for enhancing conceptual understanding and for promoting higher-order thinking skills among students” (Barak, 2014.)

As we shall see in the other reports in this series, particularly good learning results in STEM education are obtained when both teachers’ provide innovative practices, and students use ICT tools at home for school tasks. This way, ICT functions “as a sort of ‘amplifier’ of existing learning environments in homes” (Trucano, 2016).

Many tools exist to promote student-centred learning in the ICT incorporation in STEM education (Heick, 2016). As reported in INTEL (2012) “the use of ICT-based STEM pedagogy has a positive impact on student motivation, particularly for the younger age groups (e.g., through use of digital learning resources online, use of data-logging equipment to observe experiments in real-time (Le Boniec et al., 2011).” But such studies are based on very limited data and the way the technology is used must be considered alongside the frequency or type of technology used.

Complementary to Figure 9, in an extensive research work, Dix (2007a) finds that “ICT has the potential to make a significant contribution to STEM teachers and their pupils’ knowledge, understanding and skills in science”, through the use of various tools, Figure 12.
Dix (2007a) also provides detailed examples of “ways of organising the use of ICT in the science classroom, and […] strategies to apply them appropriately”. Indeed, the relationship between ICT use and STEM education reveals an extensive literature base of actual educational practice, including white papers (for instance, INTEL, 2012) and books (for instance, Kanematsu and Barry, 2016) even containing STEM lessons for both the real and virtual worlds. More to the point, LeBaron and McDonough (2009) warn about teachers’ need to constantly update contents, with the help of technology:

- “Because the nature of educational ‘content’ is changing so rapidly, teachers […] need to focus as much on skills of research and scholarly discretion as on content itself. Education can no longer rely on printed textbooks as single-source content repositories” (LeBaron and McDonough 2009).

Furthermore, real changes take time. As Hennessy and Deaney (2004) recognise, innovation and adaptation are time-consuming:

“Developing effective pedagogy around ICT involves significant input in terms of planning, preparation and follow-up of lessons” (Hennessy and Deaney 2004).
As an example of how the school ecosystem can change with technology, let us mention the comprehensive project RED\textsuperscript{12} designed to ‘revolutionise’ education through technology (Greaves, 2012). The project plans for two stages to achieve first- and second-order educational changes. In this way, the remark above of Hennessy and Deaney (2004) about the need for time for change is explicitly acknowledged: “incremental first-order changes and intervening plateaus are generally followed by transformative second-order changes” (Greaves, 2012) (see Figure 13).

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure13.png}
\caption{Revolutionising education with technology in two steps}
\end{figure}

Whereas first-order changes are adjustments to practice that can be easily learned using existing knowledge (for instance, recruiting teachers and administrators, selecting materials or adapting the curriculum), second-order changes imply “a fundamental break with current practices and require new knowledge and skills for successful implementation” (Greaves, 2012) (for instance, introducing transformative new goals and interventions to bring about novel solutions to persistent problems).

Finally, with the help of the whole educational ecosystem, “policymakers should work in concert with industry, consumers, and government agencies to establish an inclusive ICT ecosystem that encourages greater uptake and usage of digital services” (Bilbao-Osorio et al., 2013) and make sure that new pedagogies supported by ICT are effectively embedded in practice.

\textsuperscript{12} http://www.projectred.org
There is growing consensus that decisions in all aspects of ICT and STEM integration into schools and policy-making should be based on research evidence (Dix, 2007b) and, indeed, “several innovative projects in different countries have given promising research evidence about possible changes in education with ICT” (Ilomäki, 2008). So, the integration of ICT in STEM education poses a general challenge to researchers and other stakeholders:

Decisions on all aspects of ICT and STEM integration should and can be based on research evidence.

Trucano (2011) remarks that many of the criticisms of the use of educational technologies stem from the poor evidence base. Already years ago Haertel and Means (2004) called for more research and integration into practice of the knowledge derived from it. This call is acknowledged by some investigations (Dix, 2007a):

- “In response to the concern to produce usable findings, this study was born out of the collaborative partnership between researchers and policymakers focused around inquiry that is of interest to educational leaders and teachers with the intention of informing practice” (Dix, 2007a).

But the challenge should always be kept in mind by researchers in this field. However, it is difficult to obtain empirical evidence of effects on learning because of the variety of factors that influence it (Ilomäki, 2008):

- “ICT is not just a tool to be adopted […] but it has effects on several factors, like teachers’ role, teaching practices, students’ collaboration, and learning tasks.” (Ilomäki, 2008)

According to Palozzi (2006), the current baseline of empirical research on ICT efficacy is quite limited because “it is not only difficult to control variables, but also it is almost impossible to maintain experimental purity in the real-world messiness of school classrooms”.

All in all, the research on the integration of ICT into STEM T&L is increasingly mature and robust (Wellington, 2005), and builds upon an extensive literature base, which includes large-scale reviews (many countries involved, many teachers and students), as well as meta-reviews and postgraduate courses relevant for the design, development and assessment of ICT applications for STEM T&L. Furthermore, many reports, white papers and books on ICT in STEM integration have been published in the last few decades.
In particular, the reviews by Osborne and Hennessy (2003) and Marginson et al. (2013), are excellent starting points for the topics discussed in the present Report Series because they were published by experts in pedagogical research in the T&L of STEM and, although “dated” from the viewpoint of ICT, they are quite current from the viewpoint of STEM and ICT’s expectations and realities.

There are a number of questions that can be used to assess publications on how ICT activities in STEM enhance students’ understanding of science ideas and other educational effects. Four categories (taken from Hogarth et al., 2006) are indicated in Figure 14 and relate to what is investigated and how, which research tools are used, and the scope of the research.

The main instruments used in educational research include standardised surveys, interview techniques and pre- and post-analysis of the implementation (Hayden, 2011). Standardised surveys allow easier comparisons among the results of different studies.

The areas to be researched are also diverse (see Figure 15), and include (Infodev, 2015) evaluation, policy, tools used, school-wide issues, etc.

A different kind of research perspective is related to the fact that although there is a significant literature on ICT in STEM education, much of it takes the form of articles on applications for use in teaching situations: “the
emphasis has been on how to use ICT, rather than exploring its effects” (Bennet et al., 2008). On the other hand, one cannot separate the effects of ICT from how it is being used, and both aspects should be considered together. As LeBaron & McDonough (2009) show, “it is not the digital tool chosen but the way it is matched to learning goals” that matters.

Existing research can be grouped into three main topics (see Figure 16), namely specific applications of ICT (tutorial programmes, simulations, data-logging), their effects on students’ performance and the role of the teacher, and problems associated with the use of ICT (managerial and practical issues).

As a complement to the discussion around the previous three figures, let us mention that an interesting recent publication (Infodev, 2015) provides a large number of detailed research questions on the impact of ICT on learning and achievement. Divided into topics and themes, a set of fifty specific questions are formulated to help guide research into ICT in education. A thought-provoking series of “hot” topics for research in this field is also provided by LeBaron & McDonough (2009) in a meta-review of ICT in education.

As an example of a rigorous study, Hogarth et al. (2006) investigated how ICT was being used to teach science. They found studies on teaching scientific understanding and the scientific approach, on the applications of
science, on attitudes to science, and on the use of ICT for stimulating ideas about science. The research revealed a number of characteristics of the use of ICT in science education. Some of them are sketched in Figure 17.

![Figure 17: Sample Conclusions on ICT and STEM Education - (Source: Hogarth et al., 2006)](image)

Research attests to the diversity and complexity, but also the usefulness of the evidence found. Indeed, taking into account the diversity between countries in terms of the level of equipment in schools, in the level of teachers’ competencies relevant to ICT use, and also in the level of teachers’ attitudes to ICT, LeBaron and McDonough (2009) and Marginson et al. (2013) provide excellent comparisons among initiatives developed in many countries.

An area of research that is virtually unexplored is how the pressure from the bottom of society for the introduction of technology in STEM education is affecting it, Figure 18. Also, more long-term investigation of the effects of top-down programmes is needed.

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13 Note: this research was based on thirty-seven studies meeting the inclusion criteria developed for the overall research review (Hogarth et al., 2006).

14 One caveat, already mentioned, however, is the limited samples used in many of the publications, as seen for example in Hogarth et al. (2006) and in Figure 17, where only 11% of the reports included more than one school.
It is easy to find scattered evidence about the increase in motivation and excitement of students when using ICT in class, for instance using data loggers, Lego robotics, etc. In particular, “the computer as a novel tool brought some extra attraction in the first studies” (Ilomäki, 2008) (the so-called ‘Hawthorne’ effect). What is missing is systematic Education Research (ER). Since the fields of ER in Science (SER), as well as the corresponding fields for Physics (PER), Chemistry (CER), Engineering (EER), Mathematics (MER), etc., are well established, these standards of research should be followed more closely:

**ICT in STEM research must eventually come up to the standards of Education Research.**

One venue that has been explored at higher-education level, but less so in schools, is the development of standardised tests (mentioned above), and this poses another challenge:

**It is imperative to develop research-validated and standardised sets of surveys that would allow comparisons of ICT+STEM education both locally and internationally.**

All in all, there are important research-based elements missing in the integration of technology in STEM education:

- More examples of application of ER standards and of the transfer of ER into the classroom.
- More collaboration between higher education institutions – and, especially, research centres – and secondary schools.
- Large-scale transfers of existing education research (in all STEM subjects) into the classroom, to inform teachers’ practice.

Better research strategies are needed to “support educational leaders and classroom personnel to make the best use of the resources that are emerging at an increasingly rapid pace” (INTEL, 2012), and to conduct research on learning with, and not from, technology (Dix, 2007):
• “Themes and recommendations call for empirical studies capable of informing policy, which embrace longitudinal, multi-level, and multi-method design, conducted in authentic contexts undergoing change that holistically examine teachers’ practice and students’ learning with, and not from, ICT” (Dix, 2007)

The Future Classroom Lab Validation Manual, produced by European Schoolnet, was designed to provide Technology Enhanced Learning (TEL) projects, ICT suppliers and other stakeholders with an introduction to different evaluation methodologies and approaches used in school pilots. It also outlines why an action-research approach had been adopted in the numerous pan-European school pilots that European Schoolnet has run with its supporting Ministries of Education and industry partners over the last 16 years and gives an insight into how the school pilot process can be effectively managed and validated to purposefully inform educational stakeholders (Balanskat et al., 2014).

An activity that should be conducted more often (e-Skills AT report, 2014) is the analysis and possible replication of published experiences. Many countries consider ICT+STEM education a current priority, and have developed strategies that are both diverse and unrelated, so much can be gained from efforts to synthesise and learn from others’ failures and successes in these programmes (Intel, 2014). We might say, then that:

It would be important to have access to frustrated experiments or dead-end attempts in education, and not only success stories.

Finally, let us mention that the emergence of “big data” tools will certainly affect education, as ICT can provide the means of storing and analysing a wide range of data on the progress of pupils over time. And this will benefit both the students (personalised attention) and the teachers (more effective work), as well as the schools and the other stakeholders in education in a number of ways, some of which are still to be “discovered”.
6. CONCLUSIONS

We have reported on a literature review covering the basic components of the use of ICT in the STEM ecosystem in order to set the scene for the more detailed reviews on the challenges and impact on students, teachers and other stakeholders presently under preparation. The main results, as described in the main sections in the document, are as follows:

- The different “tempos”, inertias and paths of ICT and STEM innovation pose a challenge to all stakeholders involved when trying to develop STEM curricula that integrate technology.

- ICT can reinforce the student skills that STEM education is supposed to develop, such as problem-solving, logical and critical thinking, and technological literacy.

- In view of the increasing amount of information available nowadays and the greater number of ways to consume it, such as BYOD (Bring Your Own Device) and Cloud computing, schools must be equipped with the infrastructure to support current digital devices (high speed Wi-Fi and stations for charging devices).

- Decisions (as well as monitoring and assessment) on ICT and STEM integration should be based on researched evidence. This research must meet the standards of Education Research.

- Business-Education collaboration can increase the uptake and effectiveness of ICT in STEM education by aligning curricula development with skills needs for employment; by ensuring that the material and information remains up to date; and by providing real-world contextualisation and training for teachers.

Additionally, further findings, recommendations and challenges include:

The school ecosystem is changing greatly with the introduction of technology, and this change can have significant benefits but also poses certain risks.

In particular, STEM education should give students the opportunity to practise all sorts of skills acquired in science classes or projects such as: observing, experimenting, planning, evaluation skills, problem-solving skills, abstraction skills, logical thinking skills, etc. ICT tools can be used to enhance conceptual understanding and to promote higher-order thinking skills among students. Furthermore, STEM Teaching & Learning may benefit from various holistic approaches to transforming education that have been suggested by public and private stakeholders.

The digital skill set developed by the so-called “digital natives” in informal ways is usually incomplete and has to be further enhanced and refined by the school. "The skills that young people develop by themselves with regard to technology do not necessarily help them to
maximise their learning opportunities” (OECD, 2012). Important issues at stake are individual differences and needs and the range of skills required to benefit from an educational use of technology. The possible requirement (for students and teachers) to obtain a certification of basic digital skills that may serve as a starting point for skills improvement is not sufficiently widespread. In fact, the digital divide (in terms of use) also exists within the boundaries of developed countries.

Technology allows many applications in the classrooms, including teamwork. Furthermore, the recent emergence of “big data” tools will certainly affect education as ICT can provide the means of storing and analysing a wide range of data on the progress of (individual) pupils, classes and schools over time. The use of specific ICT tools in the STEM ecosystem can be designed to support models of teaching and learning that incorporate real-world applications, and include research, design, analysis, composition and communication. Successful STEM implementation requires an alignment of curriculum, learning resources, technology, teaching, and management to address all students.

The importance of the teacher in ICT integration cannot be overstated. Teachers need to extract updated contents from a variety of ICT sources, not only from printed textbooks, but they need time to develop effective pedagogy around ICT, which involves significant efforts in terms of planning, preparation and follow-up of lessons.

The research on the integration of ICT into STEM Teaching & Learning is increasingly mature and robust. Research should address the questions that educational leaders, teachers, schools and policymakers care about, exploring the effects and impact of ICT implementation, in addition to better understanding how to use it. Indeed, in-depth studies of ICT in STEM education in schools from different countries evidence a measure of robustness in the findings, which would make them of use in any other country. Still, efficient research strategies are needed to make the best use of the resources that are available at an increasingly rapid pace and to incentivise transfer of existing education research into the classroom, to inform teachers’ practice. One example is the development of research-validated and standardised sets of surveys that allow comparisons of ICT+STEM education both locally and internationally.

All stakeholders must work in concert to establish an inclusive ICT+STEM ecosystem that encourages better uptake and usage of digital services, and to make sure (via monitoring and assessing) that new pedagogies supported by ICT are effectively embedded in practice. Specifically, European employers (and intermediaries) should have an active role to help ensure that ICT in STEM education is up to date, in line with skills needs within the workforce, and provides added value for students, teachers, business and society at large.

Overall, the topic of ICT support to student education in STEM is more alive than ever, with many exciting new developments and opportunities available which provide challenges for research and classroom action. In general, continuous investigation and action research is needed to make sure that ICT are deployed in the best of pedagogical ways and fulfils the expectations placed in them by all stakeholders involved. And for this to happen, organisations and initiatives like the STEM Alliance (or similar bodies at national level) need to communicate the results of research effectively and meaningfully to the various target audiences, including policymakers and teachers.
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But we also need to become much better at using technology to support new pedagogies that focus on learners as active participants with tools for inquiry-based pedagogies and collaborative workspaces. Technology is our best bet to enhance experiential learning, foster project-based and inquiry-based pedagogies, facilitate hands-on activities and cooperative learning, deliver formative real-time assessment and support learning and teaching communities. And there are plenty of good examples around, such as remote and virtual labs, highly interactive courseware that builds on state-of-the-art instructional design, sophisticated software for experimentation and simulation, social media and serious games.

(Andreas Schleicher, Director, OECD Directorate for Education and Skills)
ABOUT STEM ALLIANCE

STEM Alliance – inGenious Education and industry, brings together Industries, Ministries of Education and education stakeholders to promote STEM education and careers to young Europeans and addresses anticipated future skill gaps within the European Union. STEM Alliance builds on the success of the inGenious initiative (2011-2014) to increase the links between STEM education and careers, by involving schools throughout Europe. With the support of major industries and private partners, STEM Alliance activities promote STEM jobs in all industrial sectors and contribute to build a STEM-skilled workforce. STEM Alliance aims to improve and promote existing industry-education STEM initiatives (at national, European and global levels) and contribute to innovation in STEM teaching at all levels of education. The STEM Alliance is coordinated by European Schoolnet (www.europeanschoolnet.org) and CSR Europe (www.csreurope.org). More information: www.stemalliance.eu