Learning and teaching technology options

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1. **Introduction**

Technology is expected to revolutionize education by, for example, blurring the barriers between teachers and students, increasing access to high quality contents developed collaboratively or making personalised and ubiquitous education a reality. However, although progress has been made, this revolution is happening at a slower pace than anticipated.

Educational technology encompasses a wide array of technologies, tools, services, and methodologies that, effectively used by teachers, students, families and school leaders, can help throughout the educational process to better achieve educational goals. Still, technology by itself does not bring benefits and, if pervasively applied in educational environments, may have unintended consequences.

Successfully integrating technology into the educational process requires creating a positive and innovative learning environment. The effect of new and emerging learning technologies on education is a complex topic with several intertwined factors affecting each other: how technology and the foundations of the learning process are related to each other, which are the main technology trends, what emerging learning and teaching methodologies are fostered by these technology trends, and how stakeholders are shaping and applying these technologies and methodologies in the different educational levels. Moreover, other relevant topics also play an important role, such as whether or not these technologies will foster further inequalities and the role of researchers and the industry—providers and consumers of education at the same time—in this new environment.

The persistent economic meltdown and the challenges facing the European society in the globalized and digitalized environment has lead Europe to a crossroad. There is no doubt that education has an important role to play in increasing the European competitiveness and reducing unemployment, but what can policy makers do to take full advantage of emerging technologies in education while avoiding their downsides?

The report intends to provide helpful insights about these complex and challenging topics by analyzing: (1) new and emerging educational technologies; (2) new ways of teaching and learning fostered by those technologies; (3) the role of the different educational stakeholders; (4) the future of education in the EU; and (5) other considerations. Based on the analysis several policy options are outlines and assessed.

2. **New and emerging learning technologies**

2.1. **The foundations**

Nowadays technology underlines most of the activities of our life: the way we work, the way we communicate with others, the way we spend our leisure time, etc. This intensive use of Information and Communication Technologies (ICT) has an impact on human beings, physically and mentally. When trying to understand the potential role of ICT in the educational process, the effects of these technologies, particularly on children, constitute an unavoidable field of knowledge that has to be considered.

This understanding can lead to the reduction of risks and the development of better services and products and, specially, more effective learning and teaching practices.
There is evidence that emerging technologies and the Internet are essentially changing how we receive information and how we, and above all young people, learn and memorize.

However, due to the limited experimental data available (most of the existing evidence comes from small-scale neuroimaging studies) and the lack of consensus among experts we might well affirm that technology and the Internet are likely to have both positive and negative effects on the cognitive development of children.

### 2.2. Technologies

In analysing the effect of technology on learning and teaching it is important to understand the main technology trends affecting the educational environment. These trends are grouped into four categories: enabling technologies, cloud technologies, devices, and technical support. Enabling technologies refer to the basic elements that make possible providing services to schools, universities, companies, and households, namely connectivity, local area networks, and technical support. Cloud is another trend that deserves specific consideration, because most of the services are shifting to the network and are not locally provided any longer. Eventually, the evolution of the electronic devices and how citizens access on-line services through these devices will shape new learning services provided through the network.

Let see in the first place the main trends regarding what we have called enabling technologies. Most of the schools in the EU have broadband connectivity and the situation has substantially improved in the last years. However, lack of ultra broadband connectivity at the school level — with speeds higher than 100 Mbps — can seriously hinder the adoption of new teaching and learning practices that require high bandwidth. At the household level,
there are high penetration rates of broadband Internet access, although with persistent disparities depending on household socio-economic status.

Digital contents, applications, and services are increasingly being delivered on demand through the Internet from shared infrastructures managed by third parties, in the so-called cloud computing model. In the educational environment it has several benefits such as fast provision of new services, easy infrastructure scaling, reducing the required initial investment, and allowing public managers to draw upon complex innovations without deep unfeasible changes in their organizations. Those are the reasons why the market of cloud computing in education is expected to more than double in the next 5 years.

Devices are being dramatically influenced by the shift from fixed connectivity based on shared personal computers towards a mobile multimedia personal connectivity characterized by fast and persistent connection and ubiquitous access. In 2018 all mobile personal devices will grow in number of shipments compared to 2013 while desktop computers and laptops will substantially reduce their market share. It is expected that in the medium term personal mobile devices, such as wearable devices, tablets, smartphones, and phablets (half way between both of them) will play a much more relevant role in the educational environment. In addition, interactive whiteboards are expected to grow in European schools because they foster a smooth way of blending technology and traditional learning. On the other hand, desktop and laptops are likely to reduce their presence in the education environment. This shift towards handheld devices will foster more flexible uses while keeping the cost low, thus opening a world of new possibilities. Other devices that have potentially relevant applications in education are game consoles and wearables.

These trends, particularly the expansion of cloud computing and the use of personal heterogeneous devices in the school, raise legal and security concerns such as privacy and data protection issues. Moreover, standardisation and interoperability of contents and services across the platforms remain a challenge.

Finally, lack of adequate technical support is considered one of the most relevant factors hindering the effective introduction of technological resources in the educational environment. After the provision of infrastructures and equipment, support and maintenance activities usually become a school issue, having neither the skills nor the budget to do it appropriately.

### 2.3. Educational Contents, Tools and Services

A new myriad of innovative contents, tools, and services is been deployed as a result of the fast evolution of the enabling technologies. Ultra broadband connections and services migrating into the cloud allow sharing information and contents and working into collaborative environments. Ubiquitous access promoted by faster mobile networks and intelligent mobile devices create new ways of communication ‘anywhere, anytime’.

The Internet has substantially changed the way in which contents are created, distributed and consumed. Production costs are reduced, blurring the barriers between producers and consumers. New communication tools allow collaborative creation and endorse creating global markets where contents can be easily provided worldwide. As a result, digital contents are becoming the most relevant source of traffic on the Internet. Educational content is not an outsider in this general tendency. No more than two decades ago textbooks were
almost the only mean to provide contents in the educational environment but the situation is shifting towards digital contents having an increased relevance, thus challenging the whole educational community. The industry, particularly the potent European publishing industry, is threatened by several factors such as: new ways of commercialisation by purchasing used or rental books; an increased demand for digital books that reduce the revenues of legacy publishers; and the emergence of new competitors with disruptive innovative business models. The Open Educational Resource (OER) movement (making educational contents and resources freely available) is both a threat and an opportunity for the industry.

These trends create amazing opportunities to increase the availability and quality of educational contents while reducing the cost. However new challenges arise for policy makers, such as guaranteeing the quality of the materials, preserving equality, defining standards that allow the interoperability of contents through different devices and platforms, and finding a healthy balance between commercial for-profit producers and open resources developed by the community.

Together with contents, the development of new services and technological tools might have a great impact on education, particularly mobile apps, social media and artificial intelligence systems. Mobile apps are expected to be a relevant and growing media to deliver educational contents and services. Currently, educational apps are the second largest category in the Apple store and the sixth largest category in Google Play store. However, only 14 per cent of current educational apps are intended to be used at school, and education apps face some limitations and risks, such as lack of standardization and quality assurance, and the need of protecting children from opportunistic behaviours from developers.

Social media, when used in the educational context, allow teachers and students to communicate and access content anytime, anywhere, particularly when accessed in mobility. Their use, in addition to providing ubiquity and flexibility to the educational process, enhances collaboration, participation and creativity thanks to co-creation of contents and knowledge. Still, and despite the learning potential of social media and the high penetration of these tools among students, its application in schools is still very low. Social media, as well as the increasing interaction of teachers and learners with web learning tools, are also a new source of information that can lead to creating personalised environments adapted to the specificities of the students, maximizing their educational performance. The analysis of the big amounts of information provided by web-based educational systems is known as Learning Analytics. Although it can substantially improve education by personalising the process to the specific needs of students, it raises security and privacy concerns that might results in an important barrier to its development.

Finally, virtual assistants might have vast application in higher education and lifelong learning and can boost self-driven learning.

3. New ways of teaching and learning

Deploying technology at schools by itself will not transform education. ICT have to be understood as an enabler of innovation in education and training in a wide sense. Innovation for learning requires a systemic approach, in which technological infrastructure (connectivity, devices, etc.) is only one dimension. Other dimensions include: content and curricula, assessment, learning practices, teaching practices, organization and leadership and
values. Technology *per se* will not perform the change Europe needs to upgrade workers’ skills, generate employment and boost competitiveness. The implementation of innovative infrastructures without innovation in the curriculum, the pedagogies and the organization, brings little improvement or even deterioration of educational performance.

One crucial element of this holistic innovation approach is the curricula. There is a general consensus over the need of a transformation. With limited exceptions, today’s curricula at K-12 level is based on broadly the same subjects as in the last decades, or even centuries, that includes mathematics, language, social sciences (arts, history, etc.) and natural science (biology, physics, chemistry, etc.). Today’s knowledge economy is requiring new skills, such as creativity, data analysis, collaboration, technology, entrepreneurship, and critical thinking. Some authors argue that the curricula should be reformed to stimulate further creativity and innovation, while others claim for a total review of its content and structure.

Together with the reform of the curricula a review of the assessment procedures is required. If the required skills are shifting, the way in which they are assessed should be modified to accurately judge if the objectives have been achieved.

Learning and teaching practices constitute the third element necessary to truly innovate and achieve an effective integration of technologies in education. The learning environment has to be transformed into a “Creative Classroom”, an innovative learning environment where teachers adopt the role of facilitators or coaches and the experience of learning for students is flexible, personalised and fun. The report includes a brief review of the most relevant trends regarding learning and teaching practices aimed at transforming the classroom: mLearning, 1 to 1, Bring Your Own Device (BYOD), self-driven learning, personalised learning and assessment, peer to peer assessment, flipped learning, game-based learning and gamification, collaborative learning and collaborative creation, MOOCs, seamless learning, and learning analytics.

4. **The role of the stakeholders**

The main stakeholders in the education system are teachers and students. However, there are other stakeholders that play a relevant role: politicians and public officials, managers (principals at school level and chancellors at university level), families, community, and the industry. These stakeholders are closely intertwined and are constantly interacting among themselves (students and families, families and teachers, teachers and principals), and the success of the education process depends on the attitude of the individuals within the group and on the interactions with the individuals of other groups.

School leaders play a crucial role, as catalysts for change, on fostering an environment where technology is smoothly integrated in the educational process by providing strategic vision, defining consistent priorities, establishing clear goals, creating a supportive environment, and developing actions to transforming closed institutions into connected open learning communities.

Teachers’ skills, attitudes, abilities and experience are the most relevant factors affecting the way technology is used in the classroom. Teachers need to be properly trained not only in technology, but in methodologies and abilities to integrate technology in the educational process. Their role is increasingly being transformed from a “knowledge transmitter” into a
facilitator or guide in the development of learners. Though, lack of teachers’ confidence in their technology skills in the EU yields teachers using technology only to prepare their classes without fostering new ways of learning and teaching.

Students are becoming increasingly active in the new digital environment by developing and sharing information and contents, giving their opinions, interacting with other students and teachers, and even assessing the results of their mates. But, inadequate digital competences of the students are also hindering the process. Although students are considered digital natives, only 30 per cent of EU students can be considered digitally competent.

Families are responsible for providing a home environment that supports digital learning. Income and parental education are closely related to children’s achievement and the successful role of families is further challenged by the digital skills of parents and their involvement in the education process. Lack of parent involvement in poorer and minority households can contribute to the computers having no effect or even having a negative effect on academic achievement of children.

In cooperating with schools, governments, and companies, Non Profit Organizations can act as venues to bring different stakeholders together to share knowledge, provide equipment, train teachers, families, and students, and raise awareness.

Eventually, the industry is another relevant stakeholder in the education arena. The main business sectors affected by the introduction of ICT in education are technology providers (connectivity, hardware, and software) and educational service providers (both traditional publishers and new eContent and application providers). The industry is the main provider of technology infrastructure, contents, and applications. Nowadays, even keeping a certain leading position, it can’t be denied that the European technology industry is increasingly threatened by innovative US providers on the one hand, and the inrush of manufacturers, mainly Asian, on the other. In fact, European position has extraordinarily weakened in the last years. As a result, the EU is missing the opportunity to lead the development of valued added e-learning products and services, while the US and Asian countries are increasingly becoming leaders in this area. This characterisation of the European ICT industry results in a particularly weak position of European companies in the education technologies sector. The sector in Europe is characterised by a strong fragmentation, small size companies and low levels of investment.

A business sector that deserves special attention is the traditional publishing sector. European publishers have traditionally held a world leading position. However, in the transition to the digital era European companies have lost their dominant position in favour of US technological companies. The current e-book sector is dominated by online distributors such as Amazon, Google or Apple. The proliferation of open educational contents worldwide is also challenging their traditional business. As a result publishers need to move from traditional textbooks to the provision of new innovative services and tools, instead of focusing merely on content. Some big players, such as Pearson, are moving into the digital arena through a strategy of acquisitions. Other players, such as the Spanish association of publishers, are creating open platforms where publishers can deliver high quality contents to the educational community. However, it is expected than the resultant market will be smaller than prior to digitisation forcing traditional publishers to substantially change their structure and to find new business models.
5. The future of education in the EU

To assess the situation of education, particularly educational technology, in European countries compared to other countries, and the consequences stemming from it for employment, productivity and economic growth, an analysis was carried out by combining data about technological education, education performance, skills, and macro socio-economic indicators from Eurostat, the World Bank and the OECD, among others.

High and stalled unemployment rates and increased competition from Asian countries are turning the productivity of workers into a strategic policy issue in the EU. Ageing population in the EU compounds the problem by forcing retraining workers in a fast evolving environment to keep the productivity level. The results of our analysis show that the EU is lagging behind China (Macau, Hong-Kong, Shanghai or Taipei) and certain Asian economies (such as Korea, Japan or Singapore) in education. Although EU countries are performing average on PISA scores and they have slightly improved in the last 3 years, Asian countries are performing wide better and improving faster than the EU. Strong disparities also arise in education performance among EU countries.

There is a strong relationship between education performance and macro-economic indicators and this relationship seems to be more intense within the EU than in other regions, particularly for unemployment rates. It suggests that the EU economy is more dependent on having a highly skilled labour force because of the more technology-based industry. In fact, although having a highly skilled population is crucial to keep competitiveness, EU has a high percentage of youth with low skills to solve problems in technology rich environments, an indicator that signals whether technology is being used in education in a manner which enables students to acquire technological skills that are applicable to the work place.

Educational technology can contribute to improving education achievements and skills of youth and to maintain the productivity level of ageing workforce, thus increasing competitiveness of EU workers in a global and fast evolving economic environment.

In considering technology at the school level, the analysis shows that best performing countries on academic achievements tend to use computers in education moderately, worldwide and within the EU. In fact higher levels of computer use seem to be related to higher percentage of students performing poorly. The conclusion is that it is not having more computers at the school or using them more often what matters.

Technology is also supposed to facilitate lifelong learning by promoting ubiquitous access to quality educational contents. Therefore it is expected that education through technology may play a pivotal role on reducing the high unemployment rates in the EU and providing new skills to older workers. However, the analysis suggests that less educated and older population are very unlikely to involve in lifelong education activities and this is particularly true for new ways of education (open and distance education) fostered by technology.

Nevertheless, these conclusions should be regarded in light of some limitations in the analysis. Educational technology is a complex topic involving multiple factors. Simple quantitative analysis can provide an overall picture but the conclusions should be taken carefully because only some of these factors are considered. This is even more challenging when considering the wide scope of this report in which all the educational levels and
technology trends are considered. Lack of specific longitudinal educational data including different uses of technology and its relationship to academic and lifelong performance hinders analysing the true casual relationships between how technology is used and the consequences on education and lifelong achievements.

6. Other considerations

6.1. Return on Investment

In the current environment of budget cuts and increasing social pressure towards public sector efficiency, performing careful evaluations of the costs and benefits associated to investments in educational technology become increasingly important. The most commonly used methodology to evaluate public investment is cost-benefit analysis.

The short-term benefits of technology in education are related to improved academic achievements, while the long-term impacts affect the individuals and the society as a whole: increased productivity and employability, higher earnings, and other intangible benefits of having a better educated population. Assessing those benefits is a challenging task. Most of the benefits are difficult to capture and quantify, particularly in the long term, and it is difficult to isolate the true causes (and therefore the costs) behind those benefits.

6.2. The second digital divide

There is a gap in Internet penetration of 40 percentage points between affluent and poor households in the EU. At the school level, although the situation has improved in the last years, between 18-28 per cent of students depending on the grade, lack access to ICT both at home and at school. Moreover, the divide is not only about infrastructures but about how technology is used. Once the infrastructure is available, the inequality emerges from the capability to properly use it, the so-called second digital divide. Digital inequalities in developed countries are arising as a side effect of the large-scale implementation of technology in schools. This knowledge gap can affect the people’s income, their social mobility and ultimately their quality of life even more than the achievement gap, and also affects productivity loss and ICT growth. Conversely, there is a valuable side-effect in solving the educational digital divide: it can speed up the process towards a more efficient fully digitalised society.

6.3. Regulation and ethical issues

The use of technologies in education encounters various regulatory and ethical issues. We have identified four main areas with legal and ethical implications that should be taken into account when deciding upon policy options: cyber security and privacy, intellectual property rights, standardisation and interoperability. In addition, the aforementioned reforms of the curriculum and assessments methodologies might also require some legislative modifications.

The increasing use of emerging technologies in education and within schools raises concerns about privacy and security issues. The use of cloud-based technologies at schools might bring risks derived of the protection of students’ private data such as: the ownership of the data, the regulatory compliance depending on the location of the data, the technical and administrative protection measures, and the transparency of agreements regarding the
disclosure and uses of students’ information. Learning analytics raise various types of ethical concerns: location and interpretation of data, informed consent, privacy, de-identification of data, and classification and management of data. Data protection policies and regulation should seek a balance between the protection of fundamental rights and promoting innovation by effectively protecting citizens while minimising their potential negative impact on the development of learning analytics products and services. Eventually, the increasing use of Internet augments risks such as cyber bullying or grooming.

One of the most relevant barriers to the development of digital educational resources in the EU is the lack of a clear and harmonized legal framework. The current European intellectual property regime hinders the creation and use of online educational contents and generates uncertainty for educators and learners.

A lack of interoperability between operating systems and platforms and a lack of portability of resources may hinder full exploitation of the benefits of educational technologies. If applications and contents don’t run seamlessly through devices, technology options are constrained and cost is increased. The mobile ecosystem is dominated by two Operating Systems (OSs): Google’s Android and Apple iOS, accounting together for over 90 per cent of the market in the EU. These companies set their own closed standards and difficult interoperability for commercial reasons. This market dominance restricts business opportunities for EU service providers and developers, thus hindering innovative learning practices.

6.4. Evaluation

Regarding technology in education it is particularly important, not only to continuously design and implement new policies, but to assess the results of these policies. Evaluating policies can be particularly interesting in the EU where results of different policies deployed at the national and regional levels can be easily compared creating a natural policy lab that could substantially improve the effect of the policies in the medium term. Evaluation should not be focused on technology itself but on how technology is integrated in the educational process following a comprehensive approach. Moreover, the effect of educational policies should consider a wide variety of short-term performance indicators and long-term achievements.

7. Policy options

As previously described Europe is lagging behind in education achievements compared to other countries, particularly the aforementioned Asian countries. Moreover, there seems to be a relationship in Europe —stronger than in other countries— between academic achievements and the stagnated economic growth and high unemployment rates. Other advanced economies, such as the US and Canada, having similar educational performance are doing better in macro-economic indicators.

A similar pattern arises when considering skills of adults. Educational technology is expected to substantially improve education performance by increasing the quality while reducing —or at least maintaining— the cost. However, there are several factors that challenge the effective deployment of educational technology in Europe, namely: (1) lack of compelling evidence of the benefits of the different technology options in education
performance; (2) persistent inequalities among European countries and within the countries; (3) increasing speed of technology evolution; (4) lack of strong involvement of the different stakeholders in the process: teachers, civil society, and the industry; (5) inadequate regulatory framework; and (6) budget pressure. Some of these factors are strongly intertwined: for example, regulation, misunderstanding the benefits and lack of stakeholders’ engagement can hinder the effective deployment of emerging technologies.

Various policy options are posed to address these challenges. These options do not focus on proposing specific technologies or projects. The education system is very wide and no technology will be adequate to solve all problems. Moreover there are many and fast evolving technologies while every region and country face specific challenges and have specific contextual factors. Making very concrete technology recommendations at the European level for the whole education system would be quite daring and would likely yield inadequate conclusions.

Therefore the different policy options are intended as strategic approaches that provide a framework for policy-makers to define more concrete policies depending on contextual factors. The policies are classified into four areas: technology, stakeholder’s engagement, competitiveness, and cross-cutting policies.

**Technology**

- Extensive deployments of technology at the school level
- Pilot based deployment
- Defining and reaching a minimum threshold infrastructure at schools
- Sharing infrastructure and services in the cloud
- Drawing upon students’ devices
- Drawing upon open and collaborative environments to create educational resources

**Stakeholders’ engagement**

- **Teachers**
  - Reforming educators’ training and assessment systems
  - Implementing specific Continuing Professional Development (CPD) plans
  - Promoting collaborative transnational educators’ communities
- **Industry**
  - Promoting Public Private Partnerships
  - Involving the industry in the policy-making process to better align its needs and education
  - Strengthening cooperation in innovation and research
  - Boosting the industry of educational contents and services
- **Families**
  - Carrying out awareness raising campaigns
  - Implementing economic incentives
  - Direct provisioning of technology and training services
8. Conclusions

The EU is facing a challenging situation with stagnated GDP growth, high unemployment rates, and aging labour workforce. Certain Asian economies, such as Japan, Korea, Singapore or China, are also performing substantially better in education achievements than the EU and other advanced western countries. This is particularly relevant for the EU because the relationship between education performance and macro-economic indicators seems to be more intense within the EU than in other parts of the world, particularly for unemployment rates. It is expected that educational technology should contribute to improving education achievements and increase competitiveness of EU workers. However, compelling evidence of the benefits of technology on education remains elusive.

In order to understand the role of educational technology to further define polices to address these challenges, the main technology trends have been analysed and their effect on new ways of teaching and learning, and how the different educational stakeholders shape this process. Other relevant considerations, such as the economic impact of technology in education, whether educational technology can foster inequalities, regulation issues, and the importance of carefully evaluating educational technology policies have also been assessed.

In analysing these topics the main conclusion is that educational technology is not a single and simple intervention than can improve education but a wide array of technologies, tools, services, and methodologies that, if adequately combined, can help students and teachers throughout the educational process to better achieve their goals. Technology by itself does not yield to better education, but how technology is effectively integrated in the educational process is what makes a difference.

As a result, the relevant question is not if governments should invest in educational technology (not investing in technology is not an option nowadays) but how should government spend the money to add more value to the educational system through technology. Policy-makers have in their hands several options to face this challenge. Technology has to be deployed at the school level taking into account the strong uncertainty regarding the benefits of specific technologies in a fast evolving and complex environment. Therefore, options should be based on existing evidence and fostering flexible models that can be easily adapted to evolving means and needs. These options should strongly involve the main education stakeholders, namely teachers, families, and the industry. Successful integration of technology in education highly relies on teachers having the skills, abilities, and methodological tools to make the best of the technology options, and on families
contributing to kids properly using the technology in adequate digital household environments. The industry can provide innovative services, contents, and tools working closely with the governments.

Current uncertainty about short and medium term impacts of integrating technology in education should be minimised by fostering research based on evidence to understand the casual relationship between technology and education achievements depending on contextual factors of the EU.
Educational technology encompasses a wide array of technologies and methodologies that are shaped by stakeholders’ behaviours and affected by contextual factors that, if adequately mixed, can contribute to students and teachers better achieving their goals.

Such a wide and complex task cannot be addressed by a simple and single intervention. Comprehensive on-going policies are required, covering technology, methodology, economic and regulatory aspects; in addition, such policies are dependent on strong stakeholder engagement. This is a new process where we must learn by doing; therefore, carefully assessing the results of the different interventions is crucial to ensuring success.