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A Review of the Impact of ICT on Learning

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PREFACE

This Working Paper brings together evidence on the impact of Information and Communication Technologies (ICT) on education and training in Europe. It reviews 20 studies and/or reports that provide empirical accounts of the significance of ICT for learning (education and training).

It has been prepared by IPTS (Institute for Prospective Technological Studies),[1] on the request of DG Education and Culture, Directorate A (Lifelong Learning: horizontal Lisbon policy issues and international affairs), in particular Unit A2 (Lifelong learning: innovation and creativity) to support its work on the use of ICT to support innovation and lifelong learning for all.

This work is part of an on-going collaboration between IPTS and DG EAC Directorate A that started at the end of 2005. Under this collaboration, IPTS will contribute to the strategic policy work of DG EAC, by conducting focused techno-economic research and prospective analyses in domains relevant to Directorate A.

Work on the future of learning and the role of ICT is being carried out by the IS Unit at IPTS as part of a research action on eApplications. This action supports the formulation of policies for the development of the Information Society in the areas of governance, health, business, learning and social inclusion. The work links the monitoring and forecasting of ICT developments with socio-economic impact analysis of selected application areas, identifies relevant bottlenecks and suggests policy options for ICT. The aim is to support the overall formulation and implementation of appropriate Information Society policies contributing to a socially inclusive and sustainable society – one of the objectives of the Lisbon Strategy.

[1] IPTS is one of the seven research institutes that make up the European Commission's Joint Research Centre.

1. Introduction

It is difficult and maybe even impossible to imagine future learning environments that are not supported, in one way or another, by Information and Communication Technologies (ICT). When looking at the current widespread diffusion and use of ICT in modern societies, especially by the young – the so-called digital generation – then it should be clear that ICT will affect the complete learning process today and in the future. Both the Member States and the European Union have dedicated effort and resources to the promotion and implementation of ICT in education and training; and they continue to do so (e.g. the EU eLearning Programme[2]). It has also been acknowledged by the European Council held in Lisbon on 23 and 24 March 2000 that there is an urgent need to adapt European education and training systems according to the requirements of a knowledge-based society.

There is, in other words, a widespread belief that ICTs have an important role to play in changing and modernising educational systems and ways of learning. There is, however, little scientific evidence of the concrete contributions of ICTs to the learning domain, despite the efforts of the last decades. Hence, there is a need to bring evidence together on the impact of ICT on education and training in Europe. This is the objective of this working paper.

It contains a review of 20 studies and/or reports which provide evidence of the impact of ICT on learning (education and training). These have been mainly selected on the basis of a mix of the following criteria:

- they review or contain empirical evidence and/or data on ICT and Learning;
- they focus on Europe; and are recent (from 2004 onwards).
- they provide visionary accounts of the future of learning.

Overall, the review provided is brief and not exhaustive but focuses on evidence of the impact of ICT on education.

The paper is presented as follows. Section 2 describes the scope for the review and explains the terms used. Section 3 reviews the available evidence on the *diffusion* of ICT-enabled learning. Section 4 assembles further evidence on the different *uses* of ICT-enabled learning by educational institutions and within educational settings. Section 5 touches upon *teacher training* and the impact of ICT, while section 6 deals with *e-assessment* and the use of *e-portfolios*. Section 7 discusses the links between ICT-enabled learning and *social inclusion*. Section 8 summarises views on challenges for learning enabled by *future technologies*. Section 9 presents the most important messages from the review.

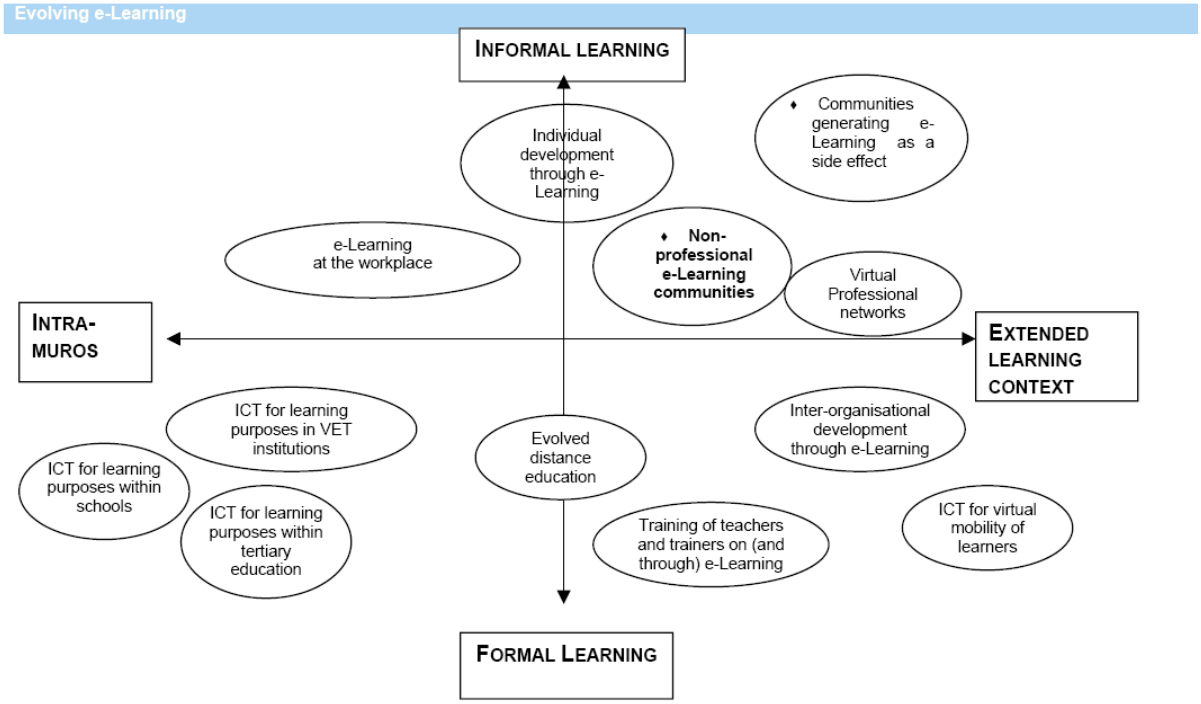
2. Scoping the review

The impact of the ICT on learning can be approached in different ways. There is no single concept of learning through the use of ICT. Many different types can be envisaged: computer-assisted learning, web-learning, computer-classes, online training, distance education, eLearning, virtual learning, digital training, etc. In this review, a broad view on ICT and learning is taken. Consequently, its impact on the learning process should encompass not only traditional learning outcomes but also the use of ICT by teachers (teacher training), the organisational use of ICT by education and training institutions, and, last but not least, the

[2] http://ec.europa.eu/education/programmes/elearning/programme_en.html

impact of ICT-enabled education on, for instance, personal development, confidence and self-esteem.

The HELIOS Observatory on eLearning proposes the notion of "eLearning Territories" as a way to better study the evolution of the different contexts of learning experiences. This would allow us to go beyond the traditional sector-based approach to eLearning. HELIOS (2006:37) argues that, as eLearning develops further, it is no longer possible to analyse it as one single phenomenon, as was the case in the past. The use of interactive learning content for instance, cannot be confined to the classroom only, as students might want to access it from their home computers. The graph below shows different territories where eLearning can be used and thus also studied.



Source: HELIOS 2006: 37

This model could be useful for studying the impact of ICT-enabled education as it becomes increasingly difficult to isolate the specific educational use of ICT to determine its concrete impact. Educational achievements are not only shaped by the way education is organised but also by the socio-economic background of the learners and their socio-cultural environments, and by changing skills and competences required for employment, education and training, self-development and participation in society. This clarifies partly why non-formal learning, informal learning and adult learning are increasingly seen as crucial for the future of learning Punie & Cabrera 2006).

To be clear about these terms, *formal learning* takes place within an organised and structured context like formal education and company training, and is intentional from the learner's perspective. Normally, it also leads to formal recognition (diploma, certificate). *Non-formal learning* usually takes place outside the traditional systems of education and training. It can be intentional for the learner but usually does not lead to formalised certificates. *Informal learning* is embedded in daily life activities and is mostly non-intentional from the learner's point of view. It is often related to experiential learning or considered as accidental learning (Colardyn & Bjornavold 2004). *Adult education* refers to learning by adults that takes place

after the formal obligatory education. Finally, *lifelong learning* embraces learning at all stages of life, from the cradle to the grave.

When the terms **eLearning** or **ICT-enabled Learning** are used in this report, they should be understood within this broad approach. Thus, none of the possible uses of ICT for learning are excluded, be they formal, non-formal or informal. This broad approach also reflects the observable shift in recent years in education from an emphasis on "teaching" to an emphasis on "learning" (Fisher et al 2006: 1).

3. The diffusion of ICT-enabled learning

This section looks at available evidence on the diffusion of eLearning and tries to address the question of how widespread it is, in terms of access and use in education and training and also in terms of geographical spread. There, is however, little reliable and comparative data available. Moreover, there are different approaches to measuring the diffusion of ICT-enabled learning. Some look at its diffusion in specific sectors, such as tertiary education, while others compare these different sectors to see where diffusion is most widespread. Other approaches look at differences between countries. Most studies seem to agree however that the traditional approach of counting the number of computers (with or without Internet) according to the number of students in the classroom is an interesting and useful comparative indicator but not sufficient to indicate the impact of ICT on education. Therefore usage should also be taken into account, both quantitatively (e.g. frequency of use) and qualitatively (e.g. how are computers used, and for what), as well as usage both by teachers/instructors and students.

Looking at the different sectors, most studies indicate that the use of ICT for learning **is most widespread in tertiary education**. The HELIOS eLearning Observatory, for instance, uses a combination of sources such as country overviews, surveys and analysis of secondary reports, to conclude that:

- Tertiary education is the sector where ICT usage is most diffused, and this is supported by significant (and often growing) public and sometimes private (though still to a limited extent) investment;
- The level of ICT usage in schools and for Vocational Education and Training (VET) is still moderate and related investments are also judged to be moderate, or low - though increasing - in the majority of countries;
- The level of usage of ICT for learning and related investment in continuous training and lifelong learning is low to moderate though more investments are being made, as in the case of VET (HELIOS 2006: 11).

HELIOS also analysed where the different European countries stand in terms of progress in eLearning. Criteria taken into account for this analysis were infrastructure and access, competitive supply of learning content and services, evolutions of learning processes and institutional structures, building of eLearning competences and rationalization of spending on eLearning. It is clear that there are great variations between Member States but HELIOS (2006: 97-105) has identified **three clusters of countries**:

- A cluster of "high performing countries" - for instance, the Scandinavian countries, the UK and Germany, where strong evidence of advancement appears across all the above mentioned criteria;
- A cluster of "average performing countries" - for instance Belgium, France and Spain, where evident advancements in the various education and training sectors justify their

relatively high rankings but where performance on the less formalised and broader socio-economic evolutions is considered relatively weak;

- A cluster of so-called "delayed countries" - for instance Greece, Poland and Slovakia, which usually presents a medium level of advancement in the traditional formal education and training sectors and little or no broader activities.

In the case of eLearning in Vocational Educational and Training, a similar distribution is observed by Ramboll Management (2005) whereby countries such as Austria, Finland, Sweden, Denmark and the UK can be considered frontrunners. These are followed by a middle group composed of the majority of EU countries, and a beginners' group which includes Portugal and Greece, and most of the new member states. Such a geographical spread may not come as a surprise, as similar rough trends are observable in terms of computer and Internet usage throughout Europe. These usage trends are highest in the Nordic countries and lowest in the new Member States and the Southern European countries (Eurostat 2005).

Consideration of the information society **context** paves the way for the observation from HELIOS that there are grounds to believe – although further verification is needed – that those countries that are well advanced in eLearning also have well developed broader education, research and innovation policies. These countries also have strong social policies addressing disadvantaged groups; and specific plans on digital content availability and accessibility (HELIOS 2006: 105).

The **eUser project,** funded by the European Commission's IST Programme, generated interesting empirical data on the use and acceptance of eLearning in Europe. eUser did a population survey in 10 Member States of the adult population living in private households in these countries. The survey mainly reflects data for 2004 as it was conducted at the beginning of 2005. The survey results contain both positive and negative messages. The major ones are mentioned below, for the domain of eLearning:

- In the countries surveyed, 12% of the total adult population (excluding students in formal education) have used the Internet during the last 12 months for formal learning activities such as looking for information on courses, doing research as part of a course, exchanging messages with co-learners, and downloading dedicated learning content;
- The spread of eLearning, narrowly defined as online courses in which a significant part of the learning content is transmitted via the Internet, was still very modest: 2% of total adult population (excluding students in formal education);
- However, the generic use of the Internet for learning was widespread amongst students: 76% of full-time formal students use the Internet in the course of organised learning. Specific online eLearning courses, however, were less diffused: an average of 8% of students took an online eLearning course in any year;
- The majority (66%) of users of eLearning courses was satisfied with the online service they used and five out of six said they would take online courses again;
- Moreover, most users appreciated the advantages of eLearning over traditional ways of learning when the full range of eLearning tools such as online discussion boards, chat, interactive lectures, and video streams were applied;
- Less positive, however, was the fact that most of those that had never followed online courses were not very convinced about them and had no intention of undertaking

eLearning: 74% of people who participated in adult education and who also used the Internet could not imagine taking an eLearning course;

- There was evidence that eLearning could extend the reach of training offers. Almost every second person taking an eLearning course stated they would not have done the training if it had not been available online;
- Home-based computer learning was also not favoured by many people: 74% of those that had computer skills but were not Internet users were not interested;
- This was probably related to the preference for the social aspects of learning. For more than two out of three of those that participate in adult education today, the chance to meet other people with similar interests is a major reason for participation;
- Also, almost 60% of people prefer guided learning be it in a traditional classroom setting or in a group with others, or with a personal instructor, as against autodidactic learning, with no guidance or learning instructions.

The eUser data indicate that there is still a long way to go before eLearning becomes fully established. A positive note is the strong potential of eLearning since most of those who had already taken online eLearning courses were satisfied with them and could thus be interested in continuing. Also the full range of eLearning tools such as discussion boards, chat and video streams were welcomed.

However, dedicated efforts are needed to get those who have not yet used eLearning services on board. Different factors must be taken into account when elaborating such efforts: access (to ICT and to eLearning providers), competence (ICT skills) and motivation (for engaging in learning via ICT). Specific combinations of these factors could then be developed to target specific groups in order to overcome the barriers that prevent these people from benefiting from the potential of the Internet for lifelong learning (Gareis 2006).

Based on the eUSer survey data, it is possible to give an account of the early adopters for eLearning. These could make up about 37% of the adult population. These are people who have already participated in adult education and who are already using the Internet regularly. The remaining population is either not/only occasionally using the Internet (7%), or not participating in adult education (24%). A range of factors have to be overcome to make these people exploit the potential of the Internet for lifelong learning (eUser 2005: 73-74).

In addition to the measurement of these formalised eLearning activities, there is another less visible dimension of ICT-enabled learning that may need to taken into account, i.e. the domain of informal learning. The problem is not only that that these activities are more difficult to measure but also that they are becoming increasingly important. Informal and non-formal eLearning activities could indeed be dramatically increasing (according to HELIOS, 2006: 11-12) and it might be true that changes are taking place at a much faster pace in informal learning than in the evolution of formal learning systems. Hence a much closer look at these activities, and at their implications for learning, employment and for fostering innovation, is needed.

4. Different uses of ICT-enabled learning

Many different uses of ICT in education are possible. These range from using ICT as tools to support traditional ways of teaching to fully ICT-enabled courses that entail a completely different way of teaching. Below is some evidence of the impact of ICT on educational

achievements and on the way ICT is used in education. It throws light on the question of whether ICT should be a supplementary tool or an enabler of change and innovation.

In its report on the use of eLearning in tertiary education, the OECD (2005) distinguishes four different levels, depending on how prominent the eLearning tools are in courses:

- *Web-supplemented courses* focus on classroom-based teaching but include elements such as putting a course outline and lecture notes online, use of e-mail and links to online resources.
- *Web-dependent courses* require students to use the Internet for key elements of the programme such as online discussions, assessment, or online project/collaborative work, but without significant reduction in classroom time.
- In *mixed mode courses*, the e-learning element begins to replace classroom time. Online discussions, assessment, or project/collaborative work replace some face-to-face teaching and learning. But significant campus attendance remains part of the mix.
- In *fully online courses*, students can follow courses offered by a university in one city from another town, country or time zone.

The types of e-learning offered by universities range right across the e-learning spectrum, but in most campus-based institutions, the growth of e-learning has not altered the fact that face-to-face classroom teaching remains central. Contrary to the predictions, distance online learning in general and cross-border e-learning by students outside the country where the institution's central campus is located have yet to emerge as significant activities. In most institutions, cross-border enrolments for e-learning are small-scale, peripheral activities and fully online courses account for less than 5% of total enrolments. Most e-learning activity is thus related to modules, or segments of a course, reflecting the dominance of e-learning as supplementary tool (OECD 2005).

But it could be that in the short to medium term, universities are less concerned with developing fully online courses. They are concentrating more on improving their on-campus programmes by using e-learning to offer increased flexibility and better access to learning content. It seems that ICT has indeed had more impact on administrative services such as admissions, registration, fee payment and purchasing than on the fundamentals of classroom teaching and learning. As a result, the OECD (2005) concludes that eLearning has not really revolutionised learning and teaching.

There are many reasons for this, such as resistance by teachers as a result of lack of time, motivation, support, reward, coupled with insufficient ICT and eLearning literacy. Educational institutions are also concerned about intellectual property rights when providing learning content online. Furthermore, they may be unconvinced by the promise of lower costs compared to conventional campus-based provision of courses. There is little evidence for this, at least in the short term, though there is a belief that eLearning could have a positive impact on costs in the medium term. This could be done by increasing the number of students taking online courses, using open source software and open source content, by more re-use of learning content and greater course standardization.

But costs are not, and should not be, the only concern. Course standardization, for example, should not reduce the diversity and creativity of learning modes and course content. The overall qualitative enhancement of the student experience is also important and is also a positive argument for increasing the use of ICT in education (OECD 2005).

Earlier research at European level confirms the OECD observation that the application of eLearning at tertiary level mostly takes the form of 'web-supplemented courses'. A study commissioned by DG Education and Culture, carried out in 2002-2003 and based on a survey of more than 200 European universities, assessed the pace of integration of ICT in universities.[3] It concluded that the general extent of integration of ICT in teaching has risen greatly since 2000, with three out of four universities in the EU experiencing high or very high rates of increase and only 3% low or very low increases. The study showed that the basis for ICT use is in place and that almost everyone at university has access to computers, the Internet and e-mail accounts. Moreover, nine out of ten universities have intranets providing information.

The study, however, also indicated that ICT is primarily used to support existing teaching structures and traditional ways of tuition. It concluded that most European universities are still at a stage where the use of ICT "consists of treating the computer as a sophisticated typewriter and as a means of facilitating communication via traditional pedagogy and didactics in the actual teaching situation" and only a minority take advantage of the potential of ICT to redesign curricula and the content of programmes (HELIOS 2006: 48-49).

The OECD has also investigated student performance at secondary level, providing evidence of the impact of ICT on concrete **school achievements**. Based on the OECD's PISA 2003 assessment of educational performance by 15-year old students, it has shown that regular computer users perform better in key school subjects compared to those with limited experience with computers or to those that lack confidence in their ability to perform basic computer functions. Moreover, it seems that availability and use of computers outside the school environment, i.e. at home - and even accounting for differences caused by socio-economic status - is a more determinant factor for school achievement than the use of computers at school. Although access to computers in schools has increased in most OECD countries and although access to computers is more universal at school than at home, computers are more frequently used at home by 15-year-old students. Nearly three out of four students on average in OECD countries use computers at home several times a week, in contrast with the 44% that uses computers frequently at school (OECD 2006).

The relationship with **student performance in mathematics** is striking. Students who have used computers for several years (37% of the total sample for more than five years) mostly perform better than average. By contrast, those who do not have access to computers, or who have been using computers for only a short time, tend to lag behind their class year. The latter is influenced by their home backgrounds: students with low home access, in particular, are likely to come from disadvantaged backgrounds. However, even taking into account socio-economic factors, a sizeable positive effect from regular computer use is evident. Students use computers at home for a wide range of functions, not just to play games. Half the students surveyed reported frequent use of word processing software and the Internet as a research tool (OECD 2006). The ELNORD (2006) study also found that pupils at home use ICT for educational purposes, as a collaborative tool. They use e-mail, chat and mobile phones to communicate with classmates, giving and receiving help when doing their homework.

The European Nordic states, which have been pioneering the introduction of ICT in learning, are also in a position to verify the benefits that the deployment of ICT have brought to pupil

[3] PLS Ramboll Management (2004), Studies in the Context of the E-Learning Initiative: Virtual Models of European Universities, draft final report to the EU Commission, DG Education and Culture, http://www.e-Learning europa.info/extras/pdf/virtual_models.

performance, to both the teaching and the learning processes, and to knowledge-sharing, communication and home-school cooperation (ELNORD 2006). The analysis of perception by headmasters, teachers, pupils and pupils' parents of the impact of ICT on learning shows a positive impact and beneficial consequences for the above mentioned actors and processes. In the case of pupil performance, the areas where such an impact is most significant include subject-related performance and learning of basic skills such as reading and writing. ICT is seen positively by teachers as a valuable tool for tailoring learning, with beneficial effects on both academically strong and academically weak pupils. Nonetheless, avoiding exclusion is still an issue. For example, not everyone enters schools with similar computer skills. More girls than boys learn all their computer skills at school. Also, disadvantaged immigrant students, whose first language is not the language of the country in which they live (i.e. a Nordic language in the case of the ELNORD study), depend more on schools to teach them computer skills.

ICT generally has a positive impact on learning but the expectations that ICT could in some ways revolutionise processes at school have not (yet) been realised. This goes beyond the use of computers by teachers since not only PCs and the Internet but also digital cameras, mobile phones and other technologies can help to change teaching processes. But clearly, **ICT has not revolutionised teaching methods so far**. The use of ICT is mostly focused on supporting the subject content. ICT-based activities by pupils are far more to do with consuming than producing. These work individually more often than together. However, the impact of integrating ICT in teaching can be measured in pupil engagement, differentiation, creativity and by the fact that less time is wasted, though the impact of ICT is very dependent on how it is used. Head headmasters typically view ICT as a valuable tool for pedagogical development but very few of them actually experience this impact (ELNORD 2006).

As with many other knowledge-based activities in modern societies, the use of ICT organisationally has not yet fully matured. The preconditions for using ICT for knowledge-sharing, communication and home-school cooperation are almost in place, though the positive impact as yet is only moderate. Many schools, teachers, pupils and parents use the ICT infrastructure for informational and collaborative purposes. The tools are mostly used for communication among teachers, while the use of ICT to support dialogue between teachers and pupils, and to improve home-school co-operation is more limited. In spite of the high volume of ICT-based communication between the teaching staff, **the positive impact on co-operation and knowledge-sharing is only moderate**. A prime example of parents-school communication is given by ELNORD (2006) in that 50% of the parents use ICT but these parents report that they feel better informed or find that the dialogue between parents and school has improved only to a moderate degree. Positive however, is that teachers do not perceive home-school collaboration enabled by ICT as too time consuming.

This is related to another trend which will increasingly affect education and training of the present and future generation of youngsters growing up with digital technologies. Many studies refer to the need for educational institutions to be adapted to the requirements of the knowledge society and to the way the **digital generation** is learning by using technologies intuitively in their everyday life. The latter is very different from their lives at schools, and this is exactly one of the problems: it is not that students do not want to learn but rather that their learning environment is radically different (Veen & Jacobs 2005: 26-28; Punie & Cabrera 2006).

The digital generation is making use of weblogs, social networking sites, podcasting, and other bottom-up ICT tools outside the formal learning environments. As the number of these

informal and non-formal learning experiences on-line rises dramatically, more attention should be paid to these trends as these experiences are often as valuable as formal ones in terms of skills development and knowledge building and sharing (HELIOS 2006: 16).

Learning with, for instance**, mobile game technologies can indeed make learning more pleasant and more effective.** Naismith et al (2004) report on a mathematics video game that used the Nintendo Game Boy Advance system to supplement traditional curricula and teaching methods. Drills in addition and subtraction were presented as a game with advanced scoring and recordkeeping, character creation and variable difficulty levels. Findings of the "Skills Arena" project were that students completed three times more exercises compared to what would be expected with traditional worksheets. Moreover, teachers found the activity was easy to administer and control. Another example of more pleasant learning was the "BBC Bitesize" initiative, which provided revision materials via mobile phones, using a downloadable Java game and SMS text messages. It proved to be so popular that the BBC had to start charging for SMS, which then led to a sharp drop in the number of users. Other problems identified with delivering learning content via mobile phones were related to the limitations of the mobile phones themselves (small screens, memory capacity, battery); to the lack of localised content which meant that certain questions were not relevant to particular students and to compatibility across devices despite the use of Java as a cross-platform environment (Naismith et al, 2004: 20-21).

When transferring learning and teaching with mobile technologies from small-scale pilots to institution-wide implementations, educators and technology developers must consider the following key issues, according to Naismith et al. (2004: 4): Gathering and utilising contextual information may clash with the learner's wish for anonymity and privacy; Mobile technologies can also enable students to 'escape' from the classroom and from what is being learned; Effective tools are needed for the recording, organisation and retrieval of (mobile) learning experiences; And the risk that certain technologies may be abandoned by students because formal learning could interfere with their personal technologies and social networks.

5. Teacher training

The need for teacher training is widely acknowledged. Teachers, trainers, and other learning facilitators have to be given the knowledge, examples and time to "adopt" ICT in their daily practice. Empowering teachers and trainers is therefore fundamental (HELIOS 2006: 16; Cartelli, 2006). One of the problems is that today's teachers need to learn to teach with digital technologies while many of them have not been taught to do so.

Teacher training should not just encompass ICT skills but rather a full understanding and complete mastery of ICTs as pedagogical tools. In a recent Futurelab review of research on teacher education (Fisher et. al 2006), two different views on how to develop teacher training on digital technologies are distinguished: retooling versus renaissance. The first instrumental model (retooling) consists of digitalising analogue processes in the same way you would retool an industrial production line. This is seen as limited since it only attempts to capture, copy and disseminate elements of 'good practice' out of the context in which they were developed. It may appear to meet short-term needs, but does little to develop reflexive professionals capable of intelligent action in fast-changing contexts. The renaissance model, on the other hand, is a more comprehensive account of teacher development, as it is based on the strong involvement and empowerment of teachers to effect change.

The challenge identified by the authors is to make sure that the technologies resonate strongly with teachers' sense of professional and moral purpose so that they can employ digital technologies fully - that is, for understanding, reflection, ingenuity and creativity, and, through these, support their own learning in new ways. The problem is that there is very little fundamental research that investigates how teachers might learn with digital technologies. Such research is needed, but it must be seen in the light of a holistic approach since many studies have indicated that the broader canvas of globalisation and the information economy influence, both directly and indirectly, how education and the work of teachers is changing (Fisher et al 2006: 4-6; 39-41).

Thus, policies on developing teacher training should look not only at quantitative measures such as significant investments and numbers of training courses but also at the qualitative impact of the actions promoted. It is particularly interesting to note that these considerations emerge not only in countries where eLearning is still in the early stages but also in countries usually considered to be forerunners. This means that the need to re-think teacher training actions emerges clearly at EU level (HELIOS 2006: 104).

The Futurelab study reveals positive results from a review of a number of UK case studies on teacher training. Although they are not representative, most of these case studies highlight positive impacts of teacher training with digital technologies, such as increasing teacher confidence and competence in the use of IT resources by providing them fully equipped multimedia portable computers (MPTP) (Fisher et al 2006: 27-28) or by supporting online teacher communities. The "Talking Heads online community" pilot showed that informal online communities can help to reduce head teacher isolation; enable head teachers to generate and exchange insights regarding practices for school improvement; and provide an effective way for gaining quick access to a spectrum of perspectives on key topical issues. Smaller communities within the network also provide an effective support environment to head teachers (Fisher et al 2006: 28-31). Another 2002 UK pilot reviewed by Futurelab on learning to use ICT for science teaching showed that for the 40 schools that participated, the impact of equipped computers (with relevant software, support by a coach and access to a dedicated website for information sharing) reached far beyond individual teachers. It prompted department-wide exploration of new teaching strategies and renewed enthusiasm for sharing and collaboration. As a result, this approach was extended in 2004 to other subjects in science teaching and integrated into the teacher training curriculum ESTUICT (Enhancing Subject Teaching Using ICT) (Fisher et al 2006: 31-35).

6. e-Assessment and e-portfolio

Training teachers to use digital technologies could also include the use of ICT for assessment of learning outcomes, although teachers are not the only actors concerned with assessment. Assessment is indeed central to educational practice and performance. Several Member States, such as the UK, are very committed to establishing an **e-assessment** strategy. This would include, according to a Futurelab literature review by Ridgway et al (2004: 2-4), different components such as ICT support for current paper-based assessment systems; online and on-demand testing; and fully implemented ICT-based tests for the assessment of, for instance, ICT capabilities.

There is good research evidence to show that well designed assessment systems lead to improved student performance. Studies have found that e-assessment can be justified in a number of ways. It can help examination by avoiding the meltdown of the current paper-

based systems through the use of spreadsheets, calculators or computer algebra in paper-based examinations. It can also help examination management by using electronic data exchange to smooth communications between schools and examinations authorities; by digitalising student work and related logistics; by improving the technical quality of tests and by providing more accurate results. Another advantage is the added flexibility for part-time or modular learners through on-demand testing. It can also facilitate assessment readjustment to new objectives, for example by providing on-demand tests with immediate feedback, and perhaps diagnostic feedback. Another advantage is that the use of interactive and simulation-based media-rich learning content paves the way for new methods of testing specific skills such as problem-solving and problem-processing skills, meta-cognitive skills, creativity and communication skills, and the ability to work productively in groups (Ridgway et al 2004: 17-19).

An e-portfolio or electronic portfolio is a digitalized record of a person's learning achievements including skills, experiences and other achievements. It offers a means of encompassing the full spectrum of student competences in a number of school subjects and of avoiding assessing only traditional academic competences. Many different uses of e-portfolios are possible. Ridgway et al (2004: 24-25) identify three distinct, but not mutually exclusive, uses for portfolios: as a repository for student work; a stimulus for reflective activity which could involve others and as a showcase enabling students to represent their 'best work'.

A literature review on the use of e-portfolios in higher education in the Netherlands (Driessen & Bodewes 2006) observed that Dutch empirical studies focussed mainly on the investigation of the impact of e-portfolios as a reflective activity. The impact appears to be quite positive, both for teachers and students. This can also pave the way for continuous use of e-portfolios within the framework of lifelong learning.

Some studies highlight, however, that teacher guidance is crucial for the use of portfolios by students and that teachers are sometimes more enthusiastic about them than students. To address this issue, it is important for students to have a sense of ownership of their portfolios. It could be possible to reinforce their sense of ownership by looking at how computer gamers develop their virtual identities, which contain actualised records of their performance and their game competences. In a review of studies on the net-generation and the way digital youngsters learn, Veen & Jacobs (2005:52) have pointed to the need to investigate such links and to better understand how similarities between learning through game and formal learning can be further exploited. The impact of e-portfolios on the other dimensions of learning such as performance and assessment has, according to the literature review, hardly been researched in the Netherlands (Driessen & Bodewes 2006). Other problems and challenges related to the use of portfolios in education are discussed by Rubens & Heinze (sd).

7. ICT-enabled learning and social inclusion

There is a considerable risk that already disadvantaged groups and marginalized people will not be able to benefit fully from the new opportunities offered by ICT. There are data available indicating that adult learning is mainly being undertaken by those who are already in a good position in terms of employment, education and social position. eLearning is considered very effective in itself for providing skills especially for those already in work, but less so for those entering the labour market and those at risk of social exclusion. The HELIOS Observatory confirms that eLearning is going deeper rather than wider, meaning that groups

at risk of social exclusion have still not been reached and those keen on experimenting with eLearning are mostly well-educated people. (HELIOS 2006: 16)

Therefore, dedicated efforts are needed to make sure that everyone is able to acquire the necessary digital competence in the information society and to learn and develop other key competences via ICT for participation in society. Learning objectives for emancipation and empowerment, such as social competence, critical thinking, knowledge sharing and cooperation techniques, are considered to be essential preconditions for inclusion, well-being and success in the knowledge-based society. ICT-enabled learning should be designed so that it embraces disadvantaged people, families and groups. It can offer new chances to those who want to learn again and to those who were not able to benefit from traditional obligatory education and training, or who were not able to perform at school. ICT-enabled learning could allow them to plug-in again though this will not happen automatically (Punie & Cabrera 2006).

There is some evidence that ICT can give greater opportunities for accessing learning to those who need it the most. The eUser survey reveals, as mentioned above, that eLearning can extend the reach of training offers. Almost every second person taking an eLearning course states they would not have done training if it had not been available online (eUser 2005: 73).

Case study research also shows positive results on the potential of ICT-enabled learning for supporting low-achievers and young people with complex lives outside the education system, but they also highlight some important challenges. The "Notschool project" in the UK involved early school leavers again in learning through the creation of a community of researchers (the young people themselves) who enter information about themselves on their own web-page, and communicate with their peers, and with tutors and mentors. Tutors "encourage interest, prompt for ideas, set formal work, assess work, look around the community and tell their researchers what's new...". The project focussed on areas such as mathematics, literacy, dance, saxophone playing, juggling and the environment. The result was that most participants who had very low levels of literacy when they joined Notschool.net improved their literacy substantially. Also over 50% of the young people achieved formal accreditation of some sort. This model, however, was thought not to work with seriously dysfunctional families. Another problem is that it is difficult to upscale and mainstream, given the number full-time equivalent staff needed (circa 1 tutor per 20 students) (Davies 2005).

Another project looked at the use of computer-simulation techniques to boost the learning experience of low achieving pupils in the 12th grade. They were doing final electricity studies as part of a blend of general and vocational education in comprehensive high schools. As a result of the use of computer simulations of electronic systems, the students rapidly developed far more independent working procedures than those anticipated by the teachers. The pupils' dependence on the teachers reduced progressively. Another positive outcome was that that it transformed the teachers' self-perception from a technical-vocational perception to an emphasis on the development of pupils' thinking skills and self-esteem (Davies 2005).

Motivation and self-esteem are important factors that can allow the less privileged to take up learning again. Learning motivation to a large extent depends on the social context of the learner, especially for the most disadvantaged. In many social contexts, the obvious levers of motivation – such as increased employability or increased income – may not be sufficient to motivate people to learn. New levers have to be found to enhance the motivation of disadvantaged categories, linked not only to professional development but also to personal,

emotional and social elements. Therefore, new levers of motivation should be focused not only on careers, but also on self-esteem (Aceto et al 2004).

It is, however, fundamental to be realistic about the **sustainability** of projects. Most of the success stories addressing disadvantaged groups need continuous support to remain sustainable on a larger scale and in the longer run. Public funding plays an important role if a project has a recognised public interest value, but it may be necessary to consider further measures - for instance, 'Public Private Partnerships' (PPPs). Case studies should contribute to proving that PPPs are an essential element in promoting ICT-enabled learning for inclusion (Aceto et al 2004).

ICT-enabled learning should not be seen as a one-size-fits-all solution. It will not be enough if it is not associated with a clear vision, a strategy and an inclusive policy which takes into consideration and attempts to simultaneously tackle several factors which contribute to deprivation (unemployment, disabilities, social exclusion, etc). But it can substantially contribute to employability, provided that research and practice efforts are concentrated on quality eLearning and that further research is conducted into the extent and nature of measurement of returns on investment in eLearning as far as the employability of e-learners is concerned. Moreover, a lot could be done to market the benefit of eLearning in terms of employability to the employers (HELIOS 2006: 15).

8. Emerging contours of future learning enabled by ICT

There is growing awareness in Europe that looking at the future of learning is important and necessary in order to better grasp the opportunities that will arise as our societies move towards an increasingly digitalized, networked and knowledge-based society. A new vision of "ICT and learning" is needed that takes into account the shifts and trends (e.g. globalisation, migration, demographics, technological progress) that are transforming the way people work, learn, enjoy themselves and make sense of their world. Preferably, this vision would be realised through a proactive strategy that envisages and anticipates future learning needs and requirements, rather than an adaptive strategy which simply reacts to new requirements as they arise (Punie & Cabrera 2006).

A number of statements have been made by renowned experts in educational disciplines and systems, which call for revolutionary changes in the way we learn and teach at the moment. There is no doubt that the role of ICT as an enabler of these changes is stronger nowadays than ever. ICT can definitely help in organizing and providing structure for the teacher's material to students, and in following progress of a given learning, in authenticating, searching and prioritising the material. It can simulate and visualise structures of physical, chemical, biological and engineering models and interact in real time with them in learning history and/or future trends. It can also help the handicapped population. ICT can be invaluable to the multilingual population, with automated translators for teachers, students and parents. Telepresence could reproduce a sense of being there so that what is learned transfers to the real world (Visions 2020: Ruzena Bajcsy).

Future intelligent environments also described as Ubiquitous Computing or Ambient Intelligence (AmI) will play an increasingly significant role in social learning and the exchange of knowledge, particularly with user-friendly interfaces working on ubiquitous, interoperable networks. AmI could prove to be relevant for such a purpose, as it will be able to integrate and communicate context-dependent knowledge more easily than current-day

technologies can. Social learning might be facilitated in an AmI environment since it can bring people from different backgrounds, cultures and contexts closer together. The intelligent environment would facilitate the sharing of experiences by making the necessary translations (Burgelman & Punie 2006).

ICT can help to overcome two enemies of learning: "isolation and abstraction" (Visions 2020: Chen & Arnold). In a decade or two, three complementary interfaces will shape how people learn. The familiar "world to the desk top" interface will provide access to distant experts and archives, enabling collaboration, mentoring relationships, and virtual communities-of-practice. There will also be interfaces for "ubiquitous computing," in which portable wireless devices infuse virtual resources as we move through the real world. The early stages of "augmented reality" interfaces are characterized by research on the role of "smart objects" and "intelligent contexts" in learning and doing. Additionally, there will be "Alice-in-Wonderland" multi-user virtual environments interfaces, in which participants' avatars interact with computer-based agents and digital artefacts in virtual contexts. The initial stages of studies on shared virtual environments are characterized by advances in Internet games and work in virtual reality (Visions 2020: Chris Dede).

A key objective of learning will be to obtain and create knowledge at the right time, in the right place, in the right way, on the right device and available for everyone**.** There will be embedded learning processes for all ages – from the cradle to the grave - for example, intelligent toys for the first few years of life, game-based learning in pre-school, and social collaboration and filtering tools in kindergartens. Communication will be increased in communities such as high schools, where prime tools will be personalized digital libraries in project-based learning with immediate access to the Internet, and with ubiquitous student-controlled interfaces.

All these tools will be used in an appropriately adapted learning style context. In colleges and lifelong learning activities, student projects will be monitored with real time assessment monitors. Students will be evaluated on work in progress, their deliverables, their timeliness, their ability to work in teams, and their communication styles that have been monitored in the process. Virtual mentors will continuously adapt student interactions with their lifelong digital profiles, and check the effectiveness of their work against determined goals. Future tools will include super simulations and sensors, intelligent laboratory objects and project management software including voice technology to facilitate communication.

Among the tools which could be used as aids to acquiring new and complex skills, gaming could be a prime one. In the medical field, the simulation and modelling of the various physiological processes are already gaining the attention of scientists and medical experts, as these simulators can teach complex skills and provide objective measures of performance (Visions 2020: Gerald Higgins). One approach for refreshing and sustaining technical skills is to allow medics and other healthcare personnel to practice procedures in simulated environments that reproduce many of the difficulties found in real emergency situations. Another example is the on-demand, adaptive case-based simulation for medical training. Finally, the digital human or virtual human will bring medical simulation to life. Next generation learning systems will allow learners to access live and recorded lectures from multiple sources. Performance-based assignments will allow learners and small groups to demonstrate levels of expertise in tasks where they are strongly motivated to succeed. Robust simulations will make possible assignments in which learners learn and test their expertise in addressing compelling assignments and problems. Teachers and learners will be able to call

on a variety of human tutors, counsellors and experts and summon a variety of automated help systems (Visions 2020: Randy Hinrichs).

The case of science learning and teaching deserves special attention, as the intersection of scientific disciplines with ICT will be at the core of educational systems in the near future. Scientists will need to be completely computationally literate, and they will simply be unable to practice science if they are not. This therefore has important implications for education policy right now. The output of computer scientists today barely meets the needs of the public and industrial computing sectors, let alone those required for future science sectors. Education policy makers need urgently to re-consider what needs to be done to produce the kinds of scientists we shall need in the next decade and beyond, not just at the undergraduate and postgraduate training level, but also at school level since today's children are tomorrow's scientists. For children, we should make teaching of computing more than just 'IT' classes. We should make the basic *principles* of computer science, such as abstraction and codification, a core part of the science curriculum. Computer science (again, not just 'computing') should be a key element of the undergraduate science curriculum and the concept of 'computational thinking' should be built into their education. Finally, computational research methods should be included in PhD student training (2020 Science).

As a general statement, it might be said that ICT proficiency will be at the centre of required skills in the future. Integrating ICT literacy will be crucial, as it means harnessing technology to perform learning skills. It must encompass the use of ICT to manage complexity, solve problems and think critically, creatively and systematically towards the goal of acquiring thinking and problem-solving skills. Literacy must also comprise the use of ICT to access, manage, integrate, evaluate, create and communicate information in order to develop information and communication skills (21st Century Skills Partnership). Finally, the role of ICT future learning should also be seen in the light of its contribution to emancipation, empowerment and self-fulfilment. Learning objectives such as social competence, critical thinking, knowledge sharing and cooperation techniques will become more and more important as we move further into the knowledge society. As a result, it is clear that thinking about the future of learning cannot avoid asking the fundamental questions about the objectives of learning (Punie & Cabrera 2006).

9. Conclusion

It is necessary to take a broad view in order to understand and determine how ICT impacts on learning. This is because educational achievements are shaped not only by the way education is organised but also by the socio-economic background of the learners, their socio-cultural environments, the changing skills and competences that are necessary for employment, education and training, self-development and participation in society. This clarifies partly why non-formal learning, informal learning and adult learning are increasingly seen as crucial for the future of learning.

There is evidence that educational achievements are positively influenced by ICT, but not only by ICT used at school. Indeed, it seems that experience with ICT at home, in particular the computer, is a more important factor for school achievement in certain cases than the use of computers at school. However, it is still the case that access and use of computers at home is shaped by socio-economic differences. Thus the socio-economic background of students continues to be important for their educational achievements.

This obviously does not mean that the use of ICT in formal education does not matter at all. On the contrary, there is evidence that it is quite significant, but it depends on how ICT is used in educational institutions. Currently, it seems that ICTs are used as tools to support and improve the existing learning process and its administration more than for their transformative potential. ICT has not (yet) been able to revolutionise learning and teaching.

It should be emphasised however that this is not just a matter of pressing a button. Realising the potential of ICT needs to be accompanied by the necessary resources and human support, and by a social and institutional environment that is open to innovation and change. Moreover, progress is still needed in providing attractive learning content and learning technologies. However, to disregard the needs of the new digital generation of learners as they enter education and training, and the new requirements of the networked, digital society is not an option either.

Most studies indicate that the use of ICT for learning is most widespread in tertiary education, followed by ICT usage in schools and for vocational education and training. The use of eLearning for continuous training and lifelong learning is regarded as low, although this does not take into account the growing fields of informal and non-formal learning.

The geographical diffusion of eLearning follows roughly other information society diffusion statistics in Europe. These are highest in the Nordic countries and lowest in the new Member States and the Southern European countries, with central Europe somewhere in the middle. This could mean that the impact of ICT on education should be seen within a wider perspective of information society policies and also educational and social policies.

The data indicate that there is still a long way to go before eLearning becomes fully established. It is encouraging, however, that a large majority of those who have already taken online eLearning courses are satisfied and could thus be interested in continuing, especially because they appreciate more than ever the full range of eLearning tools such as discussion boards, chat and video streams.

Special efforts are however needed to get those who have not yet used eLearning services on board. There is evidence from case-studies to support the inclusive potential of ICT-enabled learning in terms of specific learning outcomes and also in terms of motivation, independence and self-esteem. Such experiences would need to be brought together and tested on a larger scale, but it is of crucial importance that strategies such as Public Private Partnerships are established to safeguard the sustainability of projects.

There continues to be a need for more reliable and more comparative data. These should not only consist of the traditional indicators (e.g. the number of PCs per student) but also look at the quantitative and qualitative uses of ICT by educators and students. Moreover, as the use of ICT outside the formal learning context is becoming increasingly important, together with informal learning and adult learning, it is advisable to have a holistic view on assessing the impact of ICT on learning.

In addition, it is necessary to be proactive and to develop a stronger understanding of future learning needs and future learning environments. Prospective work on ICT-enabled learning would help to grasp the opportunities offered by ICT to prepare for learning in the 21st Century that embraces digital technologies for better learning, for better assessment of learning outcomes and achievements, for better teaching and for better social inclusion.

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Abstract

There is evidence that ICT is having a positive impact on education and training in Europe. However, this depends a lot on how ICT is being used in educational institutions and by learners, also outside educational settings. Currently, it seems that ICTs are mostly used as tools to support and improve the existing learning processes and their administration, without deploying the transformative potential. ICT has thus not (yet) been able to revolutionize learning and teaching. In order to understand the impact of ICT on learning, a holistic approach is needed that takes into account the socio-economic context, the learning environment, and teacher training. Furthermore, it includes looking at future learning needs and changing skills and competences necessary for employment, self-development and participation in a knowledge-based, digital society.

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