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Session 3: Comparative international evidence on the impact of digital technologies on learning outcomes: empirical studies

Summary

The following paper summarises the main outcomes of *The ICT impact report: A review of studies of ICT on schools in Europe.* [1] The report was written by European Schoolnet in the framework of the European Commissions ICT cluster between June and in December 2006. Its aim was to shed light on the issue of what have been the concrete results of ICT investments in schools until now, establish a comprehensive picture of ICT impact studies at national and European level and to inform policy makers and practitioners on the results of those studies including the research methods used.

The European research review looked at the evidence of 17 qualitative and quantitative based studies on the impact of ICT in two main areas:

1. Learners and learning and
2. Teachers and teaching

The type of studies included in the research review range from large scale impact studies, national inspection/ICT monitor reports, evaluations of technical interventions in schools to European comparisons and case studies.

The paper will outline shortly the approaches to assess impact as described in two major impact studies, the Impact 2 study (The Impact of ICT on pupil learning and attainment, Harrison 2002) commissioned by Becta and the elearning Nordic 2006 (Ramboll Management, 2006) which are quite distinct.

This paper will then present some of the main findings of the review with regards to the impact of ICT in these two areas and discuss implications of the findings for different target audiences mainly for policy makers and researchers.

In a final chapter it will discuss the methodological approaches used in those studies, their pros and cons in order to raise the discussion with policy makers and researchers as well as with other stakeholders on future research in this field, its perspectives and challenges.

[**Key words:** review, impact, information and communication technologies, K12 education, evidence, research, policy, learning outcomes, international]

[1] Balanskat A.; Blamire R. et al (2006): The ICT Impact Report, Download at: http://insight.eun.org/shared/data/pdf/impact_study.pdf

Background and Scope

The use of ICT in education and training has been a priority in most European countries during the last decade, but progress has been uneven. There are considerable differences of 'e-maturity[2]' within and between countries, and between schools within countries. A small percentage of schools [3] in some countries have embedded ICT into the curriculum, and demonstrate high levels of effective and appropriate ICT use to support and transform teaching and learning across a wide range of subject areas. Most schools in most countries, however, are in the early phase of ICT adoption, characterised by patchy un-coordinated provision and use, some enhancement of the learning process, some development of e-learning, but no profound improvements in learning and teaching.

Such progress has been achieved at considerable cost. All EU countries have invested in ICT in schools: equipment, connectivity, professional development and digital learning content. What does the research tell us about the return on investment in ICT? A number of studies begin to provide evidence on the impact of ICT in two major areas:

- Learning outcomes and learners
- Teaching methodologies and teachers.

Studies in focus- core review studies

The review draws on evidence from 17 recent impact studies and surveys carried out at national, European and international level. They offer evidence concerning the benefits and impact of ICT in schools in these two areas and fall into seven categories.

1. **Large scale impact studies** [e.g. elearning Nordic, Ramboll Management (2006), Impact 2, Harrisson (2002); New Technology in School: Is There a Payoff, Machin (2006)]
2. **Evaluations of national ICT programmes or initiatives** [e.g. Evaluation of ITMF, Ramboll Management (2005), Tiger in Focus, Toots (2004), ICT and school development, ITU (2004)]
3. **National inspection reports** [8 Years Education and ICT, ICT Monitor, Kessel (2005)]
4. **Evaluation of specific national interventions- large and small scale** [e.g. The ICT test bed evaluation, Underwood (2006), e.g. Interactive Whiteboard evaluation, Higgins (2005)]
5. **National research reviews** [The Becta Review, Becta (2006)]
6. **International and European comparisons** [e.g. Are students ready for a technology rich world, OECD (2004), Benchmarking Access and Use of ICT in European Schools, Empirica (2006), Key Data on ICT in Europe, Eurydice (2005)]
7. **European case studies** (Innovative learning environments for schools, Ramboll Management (2004), Ernist ICT school portraits (European Schoolnet (2004)].

Approaches to Impact

Only three of the studies [Harrison (2002), Ramboll Management (2006), Machin (2006)] consider impact as such. In these impact is seen as an effect on a wider educational policy target caused by an intervention related to ICT and is seen as the end-point of an intervention involving input, process, output and outcome. But there are considerable differences in the approaches to measure or assess impact. We will compare shortly the Becta approach to impact and the one that was taken by the elearning Nordic study 2007.

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[2] E-maturity is when organisations make strategic and effective use ICT to improve educational outcomes; see Becta: http://partners.becta.org.uk/index.php?section=bp&catcode=_be_em_02

[3] By 'schools' we refer to compulsory education which is usually from the age 5 to 16 (primary and lower secondary education) and upper secondary education usually from the age 16 to 19 depending on the country. This period of education is also referred to K-12 education, following US terminology.

In the Becta approach [4] impact is seen as the result of an intervention intended to achieve an underlying policy goal e.g. to improve school leavers' examination grades. Impact is closely related to the wider policy goal and purpose of ICT integration in schools, namely that of improving pupils' results in national tests and hence to raise standards – the headline UK education policy aim. This wider policy context determines the focus and way the ICT impact is assessed. Such research on the impact of ICT is evidence-based and seeks to establish a causal relationship between input and impact. This is the 'holy grail' of government in many countries of course but it is not easy to isolate cause from effect, especially in education where there are so many variables in play.

The elearning Nordic study (Ramboll Management, 2006) draws on the work of Becta, and also has the dimensions of input, output and impact. The wider policy target is to improve pupils' learning, the major overall objective of ICT in schools in the Nordic countries. It is assumed that there is a causal relationship between the use of ICT and pupil's learning, but 'improved learning' is arguably less measurable than England's 'raised standards'. Impact refers to the changes the activities bring about, the effect of the intervention on the target area and group, e.g. improved learning in schools.

The nature of the target area of the elearning Nordic study is more process oriented than the UK's. The actual approach of the Nordic study aims to show to what degree an impact is experienced (positive, negative or no impact) based on the self-reported perceptions of teachers and students. A particular focus is on what kind of activity and output leads to an 'experienced' impact.

Thus, the two approaches diverge on two levels. The targets are different in the first place, because the policy focuses are not the same and the UK's is arguably more quantifiable than the Nordic countries. Moreover, the nature of the education systems reflects the way ICT impact is assessed. The main difference between the UK and Nordic countries are national versus locally defined inputs and national vs. locally defined assessment of outcomes or impact. The UK has key stages and national test during a school career so that progress can be measured; other countries have school leaving exams. Comparing the two approaches to impact assessment, the UK focus is on measurable systemic indicators while the Nordic is on people and perceptions.

To summarise: **Impact** is the overall achievement of an intervention on the educational system and can be described by a variety of qualitative indicators such as 'improvements in national test' results or 'improved learning in schools' depending on the policy target. It is the **end-point of an intervention** involving input, process, output and outcome. Isolating the variable that caused the impact is problematic in education.

Key findings of the review

ICT impact on learning outcomes and learning

All the studies reviewed have identified a range of important wider benefits of ICT on learning. These include the positive impact of ICT on students' motivation and skills, independent learning and teamwork. Increased motivation leads to more attention during lessons which can be exploited by the teacher. Aspects for more individualised learning were described in a variety of ways. Students learn more independently, at their own pace and according to their needs. They also take more responsibility for their own learning process. As seen, ICT can benefit likewise academically strong and weak students and students with special needs.

Studies reveal that these benefits can not only remain technology driven but should be more intentionally exploited following a pedagogical approach. Collaboration or teamwork as well as the use of specific ICT'-s should be more strategically exploited, better planned and focused on the solving of a joint problem or given task. These skills should be much more formally be taken into account in the future as they present important outcomes of a new and changed educational context.

[4] Dr. Vanessa Pittard, Phil Bannsiter, Evidence and Evaluation, (BECTA), Presentation given at elearning conference, Helsinki, July 2006.

Overall the evidence base (actual and perceived) shows that ICT has a positive impact on attainment levels and subject related performance.

Six studies (3;4;8;10;14;15)[5] show statistical evidence that ICT can enhance attainment in subjects. UK's largest impact study shows a raise in subject performance through ICT use in English, science and design, and technology. Also specific ICT uses, such interactive whiteboards in the UK, had a positive effect on pupil's performance in literacy, mathematics and science tests compared to students in other schools. They especially improved the performance of low achieving pupils in English and impact was greatest on writing. Another large impact study in the UK, which looked at ICT impact from an economic angle, confirms ICT investment impacts positively on educational performance in primary schools, particularly in English and less so on science but not in mathematics. On an international level, the analysis of the OECD PISA results indicates that longer use of computers by students is related to better results in mathematics in PISA results.

Most opinion based studies (e.g. elearning Nordic 2006) investigating ICT impact on student performance, give a positive picture with teachers being convinced that pupil's subject related performance and basic skills (calculation, reading and writing) as well as educational achievements improve. With opinion based studies caution is needed interpreting a perceived impact of ICT as opposed to the actual impact of ICT.

Looking at the evidence, only a few studies – mainly UK studies – actually establish a direct link between the use of ICT and attainment. As mentioned above the studies trying to prove a direct impact of ICT on attainment face the difficulty of not considering other factors that affect an improved outcome, but which are likewise important.

In measuring the impact of specific ICT uses (e.g. interactive whiteboards) questions remain how far these results are transferable to other learning contexts as they much depend on the way they are used and for what purpose. However, the more embedded a specific technology was the higher was the impact, an important result with regards to integration of ICT in general.

Despite the growing body of evidence on the impact of ICT use on learners, whether it will deliver its potential depends to a large extent on how teachers use ICT within the teaching and learning process. As the evidence shows, impacting on teachers' practice has been proven to be a difficult endeavour.

ICT impact on teaching and teachers

There is considerable evidence of the impact of ICT on teaching, not all of it positive. Whereas teachers estimate a high impact of ICT on learning and learning outcomes, the perceived impact on teaching methodologies is seen much more moderate.

Most progress has been made in recent years in raising teachers' positive attitude towards ICT by realising its value for learning through more experience and embedded use. Teachers increasingly use ICT to prepare their work more efficiently and achieve time gains.

There is evidence of changes in roles of teachers either forced by the technology itself or more actively steered by teachers. In changing the teacher–student relationship, as part of the new educational paradigm, the most difficult process for teachers is to give up control and have more trust in students planning their work independently.

Literature stresses the importance that each use of ICT needs a pedagogical approach to improve learning. On the other hand the overwhelming body of evidence shows that the majority of teachers have not yet embraced new pedagogical practices. Teachers do not feel confident yet in exploiting ICT to support new approaches in teaching. Most of the teachers are still in stage of using ICT to enhance existing pedagogical practice. Current pedagogy is subject centred, and uses ICT for differentiation and project based teaching in more advanced cases. Collaboration between students is not yet sufficiently exploited.

[5] See Annex 1.

The evidence base gives important insight into the process in which teachers adopt new technologies which is has to be taken into account with new decisions being made at policy level. As some studies show (2) the majority of teachers explore ICT as a tool following a systematic approach using it:

- to enhance existing traditional practice;
- progressively built it into the curriculum;
- to transform more profoundly their teaching practice.

According to the evidence, there is continuum along which teachers adopt new technologies. We can assume schools are only in the beginning of the second stage towards the transition into a new educational paradigm. As widely acknowledged change and transformation in education which result in better learning and teaching are long term processes. Currently ICT has had an effect on some teachers but it has failed to deliver its promise on a larger scale. Better outcomes will be therefore visible only in the years to come much later than expected and hoped for on the basis of the potential of ICT. An important research finding is that ICT impacts most in e-mature schools and with e-confident teachers, suggesting that once the foundations are laid the benefits will be considerable. The challenge is to enable all teachers and schools to reach e-maturity.

The reasons for predominating traditional approaches lie in the limited impact of national training programmes as well as in outside barriers such as curriculum context, organisational set up in schools and in leadership issues.

Discussion of findings

A number of issues are raised in the discussion of findings:

1. The evidence suggests that ICT impacts most in primary schools in native language (i.e. English in the studies) and science. The implication is therefore that funding and efforts are most profitably directed in this direction.
2. While it is of course good news for ICT advocates those who have approved expenditure and those who have implemented ICT to have firm evidence that investment in ICT has clear outcomes, they raise several questions:
   - Is it sound policy to concentrate resources on ICT for those subjects and sectors (i.e. primary schools) where results are proven? Will this not ultimately be divisive and reinforce success, disadvantaging secondary schools and other subjects than mother tongue and science?
   - What remedial interventions could improve the pay off in mathematics and other subjects to the levels of mother tongue and science, for example?
   - Do we need to show teachers more strategies to use ICT also in other subjects? [6]
   - Should secondary education be remodelled more like primary schools to take account of the greater impact in primary schools?
3. The evidence for mathematics is less compelling than for English and science, but we do know that longer use of ICT by young people is linked to improved mathematics scores. In that case, what should be done to overcome digital disadvantage?
4. There is a growing gap between high and low e-confident teachers and schools. Where ICT is extensively used the benefits begin to take off. This 'tipping point' implies that there is a period when results do not seem to justify the investment, and then suddenly everything takes off and added value is considerable.
5. A clear finding is that teachers' practice is not changing much when they use ICT. Is this desirable? What is the likely scenario when e-confident children become frustrated in e-immature schools?
6. Many of the findings relate to the United Kingdom and to England in particular. They are mostly in English. There are gaps in what is known about other countries. No doubt some evidence exists and efforts should be made to identify it and ensure it is translated. If it does not exist, efforts should be made to support trans-national studies to ensure good coverage and reliable results.

[6] According to the latest Eurobarometer Benchmarking survey 24% of teachers claim their subject is not suited for the use of ICT (Empirica, 2006).

7. To what extent are results transferable or are they contextually dependent? Can we deduce, for example, that investment in ICT in French schools will yield similar gains in test scores in French in primary schools?
8. The preceding sections of this paper have reviewed a number of European ICT impact studies. As seen above, they provide a number of key findings and lessons for the future. However, we can pose a challenging question that goes beyond the evidence and ask: *Are the results are as good as they could be*? *What are the optimum outcomes of ICT*? or *Who are we comparing with?* The evidence does not show massive gains, particularly as regards attainment and institutional development. Are the gains sufficient? If not, how could schooling be remodelled in order to exploit technology more fully? What are the optimal schooling environments for ICT investments to pay off?
9. The review shows that current education systems hinder ICT impact and correspondingly impact studies and evaluations often measure against traditional systems. Are researchers looking at the wrong outcomes? And are policy-makers clear or realistic about what they expect the results of ICT investment to be?
10. The picture of evidence is only representative for the countries in focus. These are quite e-mature countries on a wider European scale; there are still large differences between countries[7]. What about the evidence in those countries and how can we gather it?
11. In what sense can we relate country specific outcomes to national ICT policies and can we find that national policy influences the way research deals with impact issues?
12. Changes in education are long term changes. How can we speed up the change processes in schools?

Research methods to reveal impact of ICT on learning and teaching

There are currently two tendencies to identify impact on a larger scale. In the UK approach focus is on proving the causal relationship between ICT and better learning outcomes in national tests (measurable systemic indicators), whereas the Nordic impact approach is on the perception of teachers and learners.

Measuring ICT impact against students' attainment and improvement of their basic skills is one way of impact assessment, but one which assumes a fixed education system in which school learning is primarily about mastering of a pre-determined body of knowledge, skills and understanding.

Looking at the studies reviewed, only a few of them (ImpaCT2, ICT Test Bed, Impact of Interactive Whiteboards, Impact of Broadband in schools) have provided *concrete* evidence of impact of ICT on attainment measured against national or other test scores. And it is not accidental that most of these studies are conducted in the UK. Indeed, this evidence-based approach fits into a wider policy adopted in the UK according to which decision making should draw upon the findings of scientific research. In other words, the findings of the above mentioned studies, conducted of behalf of the DfES, serve as a basis for the evaluation of the government's ICT initiatives for schools (evaluative research), as well as for shaping future e-learning strategies and making choices of action. They aim to answer the question of whether the considerable increase in ICT investment paid off by making a *real* difference to educational standards.

However, sometimes it is possible that researchers measure the 'wrong things', looking for improvements in traditional processes and knowledge instead of new reasoning and new knowledge which might emerge from the ICT use. In other words, in some cases there might be a mismatch between the anticipated gains (and the methods used to measure them) and the nature of learning which is promoted by the use of different ICT environments. There is a need to evaluate more concretely learning situations or teaching processes to show under which circumstances ICT based activities can enhance the learning and improve skills.

[7] UK and Denmark, are for example countries where almost all teachers use ICT as a teaching aid as supposed to countries such as Greece or Latvia where only 36% and 35% of teachers do so.

There are also other approaches to garnering such evidence that can be as informative. For example other reviewed studies, notably the e-learning Nordic 2006 study, the evaluation of the Danish ITMF project, the Norwegian PILOT project, the Dutch ICT monitor follow an opinion-based approach. Based mainly on teachers' and pupils' responses to questionnaires specifically designed for each project, as well as on findings from case study analysis, they aim to show the *transformation* effected in the learning and teaching process as a result of the ICT use. The outcomes from the studies reported here are positive about the impact and the potential of ICT, yet, they are primarily based on the *perceptions* of teachers and pupils. In that sense, one could assume that there is insufficient evidence to identify the *actual* impact of such technologies upon learning either in terms of classroom interaction or upon attainment and achievement.

Indeed, the data may not show the actual impact, but it is the view teachers and pupils themselves hold and express about the consequences of using ICT in schools. After all, according to the OECD definition *'all the available body of facts or information indicating whether a belief or proposition is true or valid is regarded as evidence'*[8]. However, although this approach provides very useful in depth qualitative data (e. g. indications that there is a perceived positive impact especially in terms of subject-related performance, improvement in pupils' basic skills, motivation, self-esteem, confidence and independent learning), it does not provide an adequately comprehensive measure of the learning experience with ICT unless augmented with more detailed data, such as why do teachers and pupils and others think ICT delivers and under which circumstances, which can only be done by in depth case studies.

More specific interventions, such as the evaluation of the IWB project or the test bed project also provide rich data including different kinds of quantitative and qualitative evidence. They include specific classroom observations but also look at the wider picture in schools and changes over a longer period of time. However, findings are related to a quite specific ICT use or uses and the ambition of a sustained and embedded ICT use. Limitations remain in the generalisation and transferability of the findings in a wider context, where the project specific conditions can not be met.

Large-scale comparative studies such as PISA (OECD, 2004) or Eurydice (2004) face the contrary problem. They show impact areas and provide important baseline data by looking at the general integration of ICT in education systems in Europe. But they do not give an insight on the quality of teaching with ICT and do not show circumstances or success factors. Such baseline data as the use of ICT as a tool (Eurydice) should be further qualitatively enhanced with results of case studies[9] in order to have a clearer qualitative picture of how ICT impacts on teaching, making generalisations on a European level possible.

The combination of quantitative and qualitative approaches that is now applied in most of the national studies is needed to gain meaningful insights into teaching practices. A combination of different methods increases the validity and reliability of the body of evidence. Moving beyond baseline data of ICT use towards detecting innovative pedagogical practice, patterns of use and educational trends is a promising approach.

Annex 1: Index of core review studies

[8] 'The new Oxford Dictionary of English' (1998) Clarendon Press: Oxford
[9] In the line of previous project approaches such as: SITES M2 project, or the OECD qualitative case studies on ICT in schools and Learning to Change: ICT in Schools (OECD 2001)

Annex 1: Index of core review studies

Title of Study	Country	Short Reference	Ref. no. in text
The Becta Review 2006: Evidence on the progress of ICT in education'	UK	**Becta (2006)**	**1**
ImpaCT2: Learning at Home and School- Case Studies	UK	**Comber (2002)**	**2**
ImpaCT2: The Impact of Information and Communication Technologies on Pupil Learning and Attainment	UK	**Harrison (2002)**	**3**
Embedding ICT in the Literacy and Numeracy Strategies: Final Report	UK	**Higgins (2005)**	**4**
How boys and girls are finding their way with ICT?	EU	**Eurydice (2005)**	**5**
Key data on ICT in schools in Europe	EU	**Eurydice (2004)**	**6**
ICT Education Monitor: Eight years of ICT in schools	NL	**Kessel (2005)**	**7**
New technologies in schools: Is there a pay off?	UK	**Machin (2006)**	**8**
Pilot: ICT and school development	Norway	**ITU (2004)**	**9**
Are students ready for a technology rich world? What PISA studies tell us?	International	**OECD (2004)**	**10**
Elearning Nordic 2006: Impact of ICT on Education	Fin, Se, No, Dk	**Ramboll Management (2006)**	**11**
'Evaluation of ITMF: Overall Results',	Dk	**Ramboll Management (2005)**	**12**
Tiger in Focus: Executive Summary	Estonia	**Toots (2004)**	**13**
ICT Test Bed Evaluation-Evaluation of the ICT Test Bed Project	UK	**Underwood (2006)**	**14**
Impact of broadband in schools	UK	**Underwood, (2005)**	**15**
Ernist ICT Schoolportraits	EU	**European Schoolnet (2004)**	**16**
Benchmarking Access and Use of ICT in European schools	EU	**Empirica (2006)**	**17**