European Schoolnet

DECEMBER 2006

THE ICT IMPACT REPORT

A REVIEW OF STUDIES OF ICT IMPACT ON SCHOOLS IN EUROPE

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Education and Culture

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This report was written by European Schoolnet in the framework of the European Commission's ICT cluster.

Table of Contents

Executive Summary	**2**
1. Introduction	**11**
2. Aim and background	**14**
3. Methodology	**15**
4. Overview of studies examined	**17**
5. Description of impact	**23**
6. Impact on learning and learners	**25**
6.1. ICT and pupil attainment	25
6.2. Impact on learners	29
6.3. Research methods to reveal impact of ICT on learning outcomes	33
7. Impact on teachers and teaching	**36**
7.1. Impact on teachers	36
7.2. Pedagogical practice	39
7.3. Research methods to reveal impact of ICT on teaching	46
8. Barriers for effective ICT use in schools	**50**
9. Summary conclusions	**55**
10. Discussion of findings	**60**
11. Recommendations	**62**
12. References	**66**
Annex 1 Index of core review studies	**70**
Annex 2 Overview of impact areas by study	**71**

Executive summary

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[1]' within and between countries, and between schools within countries. A small percentage of schools [2] 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 and evaluation tell us about the return on investment in ICT? A number of recent studies begin to provide evidence of the return on investment and this study, carried out in the framework of the European Commission's ICT Cluster work, addresses the question of what have been the concrete results or impact of ICT investment and integration in schools in two major areas:

- Learning outcomes and learners
- Teaching methodologies and teachers.

The aims of this review are to:

- Establish a comprehensive picture of ICT impact studies and their impact areas at national and European level (Chapter 4, Annex 2);
- Give a reference framework for describing impact looking at the approaches taken in two major impact studies (Chapter 5);
- Inform policy makers and practitioners on the results of these studies including the research methods used (Chapter 6 and 7);
- Reflect critically on these findings and raise the discussions with policy makers (Chapter 10);
- Give policy recommendations and make suggestions for future action on the basis of the evidence available and emerging from the discussions with the ICT cluster (Chapter 11).

Studies in Focus

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 (Chapter 4):

1. **Large scale impact studies** [e.g. elearning Nordic, Ramboll Management (2006), Impact 2, Harrison (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)]

[1] 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

[2] 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.

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)].

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. Chapter 5 explores what is meant by impact.

Key Findings

The key findings from the studies are summarised below. They are headlines of course, and may sometimes appear contradictory (e.g. regarding the impact on mathematics); the reader is therefore urged to refer to the evidence base, specific context and caveats in the original reports and studies.

Impact on learning and learners

Six studies under review are **more quantitative based** and tried to establish a causal link between use of ICT and students' outcomes based on analysing the statistical relationship between use of ICT and students' results in exams or tests. It led us to summarise the research of ICT impact on learning outcomes in eight statements:

1. ICT impacts positively on educational performance in primary schools, particular in English and less so on science and not in mathematics (8)[3].
2. Use of ICT improves attainment levels of school children in English- as a home language- (above all), in Science and in Design and technology between ages 7 and 16, particularly in primary schools (3).
3. In OECD countries there is a positive association between the length of time of ICT use and students' performance in PISA mathematics tests (10).
4. Schools with higher levels of e-maturity demonstrate a more rapid increase in performance scores than those with lower levels (14).
5. Schools with good ICT resources achieve better results than those that are poorly equipped.
6. ICT investment impacts on educational standards most when there is fertile ground in schools for making efficient use of it (8).
7. Broadband access in classrooms results in significant improvements in pupils' performance in national tests taken at age 16 (15).
8. Introducing interactive whiteboards results in pupils' performance in national tests in English (particularly for low-achieving pupils and for writing), mathematics and science, improving more than that of pupils in schools without interactive whiteboards (4).

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.

Other studies led us to make a further four **more qualitative based** statements about the impact of ICT on learning outcomes. They are mainly based on opinions of teachers, students and parents.

1. Pupils, teachers and parents consider that ICT has a positive impact on pupils' learning (11,16,9)

[3] Figures indicate the reference number of the study providing this evidence (see Annex).

2. Pupils' subject-related performance and basic skills (calculation, reading and writing) improve with ICT, according to teachers (11).
3. Teachers are becoming more and more convinced that the educational achievements of pupils improve through the use of ICT (7).
4. Academically strong students benefit more from ICT use, but ICT serves also weak students (11).

Chapter 6 and 7 examine in detail the findings of these studies first on learning and learners and then on teachers and teaching. They also look at the research methods to reveal impact of ICT on learning and teaching.

On **learning and learners**, the studies indicate benefits for:

Motivation and Skills

- A very high 86% of teachers in Europe state that pupils are more motivated and attentive when computers and the Internet are used in class. (Empirica, 2006). However, in some countries there is a substantial number of teachers (overall 1/5 of European teachers), who deny that there is much of a pedagogical advantage of computer use in class (17).
- ICT has a strong motivational effect and positive effects on behaviour, communication and process skills (2, 16).
- Multimedia and interactive content on interactive whiteboards is engaging and motivating, particularly for primary pupils, and students pay more attention during lessons (4, 16).

Independent learning

- ICT allows for greater differentiation (especially in primary schools), with programmes tailored to individual pupils' needs (11).
- Pupils state that they do assignments more their own way when using a computer and their parents consider that they solve assignments more at their own level (11).
- Teachers consider that pupils work more in cohesion with their own learning styles, resulting in a favourable impact on both academically strong and weak students (11).
- Pupils with special needs or behavioural difficulties gain in different ways from the use of ICT (11,9)
- ICT use at schools can help to minimise the social divide by reducing the digital divide (11).
- Students assume greater responsibility for their own learning when they use ICT, working more independently and effectively (9).
- ICT offers learners assignments better suited to individual needs and makes it easier to organize their own learning, through the use of, for example, digital portfolios (9).

Teamwork

- Collaboration between students is greater when they use ICT for project work (11, 7).

Impact on teachers and teaching

There is considerable evidence of the impact of ICT on teachers and teaching.

Increased enthusiasm

- Government interventions and training programmes result in positive attitudes towards ICT in teachers (9, 11, 4).
- Issuing teachers with their own laptop computer increases positive attitudes towards their work (Becta, 2003).

Increased efficiency and collaboration

- An overwhelming majority of teachers in Europe (90%) use ICT to prepare their lesson (17).
- Teachers use ICT to plan lessons more efficiently and more effectively. ICT increases efficiency in planning and preparation of work due to a more

collaborative approach between teachers. ICT enables teachers to cooperate more and share curriculum plans with colleagues and managers (4, 3).

- Primary teachers consider ICT to have more impact than secondary teachers (11).
- Effective exploitation of Information Management systems leads to increased and formalised cooperative planning between teachers, and this has a positive impact on teaching practices. However, there is not a positive picture of the use of Learning Management Systems or Virtual Learning Environments for pedagogical purposes. They are predominantly used for administrative purposes (14, 7, 15, and 11).

Specific ICT uses

- Providing structured approaches to Internet research develop students' search and research skills which are transferable across the curriculum (1).
- Broadband is a major factor in increasing collaboration between teachers. Embedded, reliable and high-capacity broadband in the classroom increases the quality and quantity of educational activities that can be undertaken (15).
- Interactive whiteboards make a difference to aspects of classroom interaction (4).
- Government interventions have impacted on ICT on teaching and have led to a 'routine' use of embedded ICT (9, 12, 4).

Teachers' competencies and use of ICT

- Teachers' basic ICT skills have increased dramatically (7, 17).
- Teachers use ICT to support existing pedagogies. ICT is used most when it fits best with traditional practices (14).
- National competence development programmes have had limited impact on teachers' *pedagogical* competences. School leaders estimate that the impact of ICT on teaching methods in their school is low (11).
- Teachers teaching science, mathematics and computer science and active in vocational education are the most intensive users of the computer in class using it in more than 50% of their lesson (17).
- The greatest impact is found in relation to teachers who are experienced users and who from the start had already come far with the integration of ICT in their teaching. Teachers who perceive a highly positive impact of ICT use ICT in the most project-oriented, collaborative and experimental way. With ICT, the teacher tends to become more of an advisor, critical dialogue partner and leader for specific subject domains (12).
- The impact of ICT is highly dependent on how it is used. The impact of a specific ICT application or device depends on the capacity of the teacher to exploit it efficiently for pedagogical purposes. Factors beyond the teacher's control influence ICT uptake, e.g. institutional cultures, leadership, the curriculum and assessment (11, 12).
- ICT can enhance teaching by enhancing what is already practiced or introducing news and better ways of learning and teaching (16).
- Teachers do not yet exploit the creative potential of ICT and engage students more actively in the production of knowledge. Teachers' use of ICT for communication with and between pupils is still in its infancy. ICT is underexploited to create learning environments where students are more actively engaged in the creation of knowledge rather than just being passive consumers (7, 11, 12).

Barriers

Research has also identified barriers to ICT uptake in schools and this is discussed in Chapter 8. The factors that impede the successful implementation of ICT in teaching are identified in the studies as the following:

- **Teacher-level barriers**: Teachers' poor ICT competence, low motivation and lack of confidence in using new technologies in teaching are significant determinants of their levels of engagement in ICT. These are directly related to the quality and quantity of teacher training programmes.
- **School level barriers**: Limited access to ICT (due to a lack or poor organisation of ICT resources), poor quality and inadequate maintenance of hardware as well as unsuitable educational software are also defining elements in teachers' levels of ICT use. Moreover, the absence of an ICT dimension in the overall schools' strategies and

their limited experience with project-oriented activities supported by ICT, are decisive in determining levels of ICT use by teachers.

- **System-level barriers:** In some countries it is the educational system itself and its rigid assessment structures that impede the integration of ICT into everyday learning activities.

The above findings lead to a number of summary conclusions, and these are presented in Chapter 9.

Discussion of Findings

A number of issues are raised in the discussion of findings (Chapter 10):

1. The evidence suggests that ICT impacts most in primary schools in the home 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? [4]
   - 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.
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?

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

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[5]. 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?

Recommendations

The following recommendations result from the evidence of the review, from in depth discussions with the ICT Cluster and feedback from a number of ICT in education experts.

Policy makers (national, regional and school level)

1. Plan for transformation and for ICT

Support the transformation process and management of change, of which ICT is an enabler and amplifier. The key word is transformation. If the organisational and institutional context does not support new working methods, educational practices will not change. Taking into account that most teachers embrace new technologies in a step by step process, systematically but slowly, any change should be supplemented by process management and connected to realistic visions. This means allowing schools to experiment within given boundaries. The same holds true for more drastic changes, which are more difficult to achieve.

2. Include new competencies in the curricula and in assessment schemes

Most of the reviewed studies show that ICT impacts on competency development – specifically team work, independent learning and higher order thinking skills – that are not yet recognised by many education systems. These competencies should be formally included in the curricula and ways of assessing them explored. They are important outcomes of a new and changed educational context.

3. Implement new forms of continuous professional development in a workplace environment and as part of a culture of lifelong and peer learning

New approaches to teacher training should be much more related to the concept of lifelong learning, knowledge sharing and peer learning. To be confident teachers must be able to upgrade their ICT skills and gain more pedagogical knowledge and this in a much more active way than previously. Teachers have to become active shapers of their own learning process which requires a professional environment and culture that allows teachers to do so. An experimental approach using ICT in everyday practice is an important factor in increasing teachers' pedagogical competence. Training programmes should be more school-based and adapted to the particular needs of teachers and fit to personal and subject specific needs, or project related needs. Continuous professional development should be in the foreground enabling teachers to learn how to upgrade their skills. Up-front sessions should be replaced by practice oriented projects in the practical working environment. Initial teacher training for ICT, not tackled in this review, is also seen as an important area for improvement in the future, next to concrete measure for improving in service teacher training.

4. Built up a clear political will and invest in ICT consolidation

The countries analysed in this study did benefit from high ICT investments and a strong political will to foster ICT in education. Without that wider impact on teaching and learning can not be achieved. The evidence showing that ICT impacts most with e-mature schools and teachers suggests that there is a take-off or tipping point in ICT use. Before that point, little change appears to be happening and investments seem to have little pay-off. Once the change occurs the benefits accrue. Work towards ensuring the majority of schools (80 per cent by 2010 for example), not just the early adopters, reach the point of e-maturity. One way forward is to make use of the existing potential of e-confident users (students,

[5] 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.

teachers, head teachers, ICT support) in and around schools (parents, community centres, librarians, museums).

A second important issue for ICT consolidation is the focus on content and support services in schools. The value of access to good interactive digital content is essential for the successful implementation of ICT. The lack of access to appropriate digital content, related copyright issues and costs of licenses was identified as a major barrier for ICT use in schools and more actions and solutions are needed on national and European level. One recommendation is to join together the paper-based and digital content market, and harmonising licences approaches and accreditation of content. There are ways to reconcile aggregated purchases while maintaining autonomy and independence of individual institutions (e.g. a framework agreement based on actual usage). Sufficient ICT support services and maintenance contracts ensuring quality equipment for schools are indispensable conditions to achieve wider impact with ICT in teaching and learning.

5. Motivate and reward teachers to use ICT

As the survey has shown, in addition to access to infrastructure and content and having the requisite skills, teachers' motivation is a critical factor in ICT adoption, and this is often neglected. On a European level, there are considerable discrepancies with regards to motivating teachers. Actions should be built into policies that encourage teachers to use ICT more – and more effectively. Policies in this area should include measures raising the confidence levels of teachers (sufficient on-site support, appropriate in-service and initial teacher training in ICT) but also means of incentivising, recognising and rewarding the use of ICT (such as appraisal schemes, making good ICT use part of career paths, or time benefits for teachers engaged in ICT related projects).

Schools

6. Integrate the ICT strategy into the school's overall strategies

As the latest evidence confirms teachers that assess to experience a more positive impact of ICT are most likely to be found in schools where headmasters have used ICT to support the development of the school's values and goals. If the ICT strategy is integrated into the school's overall strategy ICT has the greatest potential to act as a catalyst for change. Furthermore this overall strategy needs to be developed and evaluated by all school actors and not only by the headmaster in collaboration with the ICT coordinator, thus establishing a culture of collaboration and commitment and making it more likely that the policy is actually solving a problem that teachers and students are facing. Communicate about your objectives with teachers, students and parents in order to take away wrong expectations, unnecessary fears and manage doubts.

7. Transform positive attitudes towards ICT into efficient widespread practice

Schools should capitalise on positive attitudes. To achieve greater impact it is important that teachers underpin ICT use with a pedagogical approach. There seems to be a mismatch between the potential of ICT for learning and the actual teaching approach of teachers. The majority of teachers think that ICT can improve learning outcomes, but they think that ICT has little or no impact on their methodology. This could be achieved by hand on practical training, providing easy to use ICT based materials, peer learning and peer sharing of experiences, securing reliable infrastructure, triggering teachers knowledge in their subject, pupil motivation, and easy access to research findings.

Research and Development

8. Consider context-sensitive and process- oriented research methods

In such a complex field as education and pedagogy, qualitative methods are necessary to investigate impacts. There is a need to go beyond pure observations and evaluate more concretely school contexts, learning situations and teaching processes to show under which circumstances ICT based activities can enhance learning and improve skills. This requires some degree of qualitative interpretation, in order to evaluate the causes of impact which have been observed. A holistic approach to identify impact is needed. What works for whom in what circumstances is what policy makers/ shapers need to know.

Apart from research that shows benefit for ICT in subject, research should be conducted to find out how ICT can positively influence the learning process. How ICT can support certain learning processes and thus raise attainment will require a process oriented approach in evaluating impact of ICT for the future. Further research is needed into detecting the impact of ICT on these wider competencies and innovative pedagogical practices behind them.

9. Create closer links between research and practice

More fundamental research, small scale, focussed research on specific ICT tools should be combined with research which is much more closely linked to practice: Ways forward are to develop a critical and reflective attitude amongst teachers or teachers carrying out research themselves (coached by researchers) and involving schools in defining research questions.

Furthermore the results of research should be made available to practitioners in a way that it is useful for them (evidence leaflets, easy access to research evidence and appropriate ways of communicating main research findings).

10. Encourage more qualitative trans-national research into ICT impact

This paper has gathered evidence relating to the impact of ICT on learning outcomes, teachers and teaching that has largely arisen in national contexts (with the exception of the e-learning Nordic study). It has been assumed that the results are likely to apply in other countries but this may not be true. International comparisons should move beyond baseline data and give more qualitative insights into ICT use by learners but even more by teachers.

11. Make national research into ICT impact accessible

As the review shows there is a geographical imbalance of national evidence of ICT impact across Europe. Either there is a lack of the relevant research and/ or the research is difficult to access because of language and fragmentation of research, specifically in federal systems. It is therefore recommended to:

Set up mechanisms on European and national level that allow us to know better the results of such research, e.g. set up a repository of abstracts of national, European and international research. This should include various types of research small and large scale.

12. Rethink the approach to evidence and its relation to decision making

The overview of the different research approaches already taken in that field can help policy makers to decide on a specific national approach suited to their education goals and context. However, policy makers should consider the following: 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. ICT can be used in a variety of ways; the benefits and impact of ICT therefore vary likewise. The review has shown that impact on education is heavily dependent on the political objectives and hardly measurable within traditional educational standards. Research should therefore not focus on ICT alone, but include wider topics such as innovation and find instruments to capture and detect unexpected results and processes.

13. Support both large and small scale studies on ICT impact and base decisions on both quantitative and qualitative evidence

Any quantitative data from large scale national studies should be complemented with qualitative data arising from smaller scale studies or research projects. The advantage of small case studies is that they are context depended which large national/ international studies often fail to deliver. In turn, any qualitative evidence should be enhanced with quantitative data arising from independent, critical, longitudinal and large-scale studies with experimental and control groups to test the claims made for pedagogy, e.g. a raise in attainment or an endured change. A clear advantage of international large-scale studies is that they are independent from national contexts and policy goals.

Annex 1 of the full report provides an overview of the studies and their reference in the text to help the reader to relate each finding to the respective study. **Annex 2** lists the core review studies according to their scope, research methods and, most importantly, identifies the areas where impact has been shown. This can help policy makers to identify studies most relevant to their interest.

1. Introduction

The use of ICT in education and training has been a key priority in most European countries during the last decade, but progress has been uneven. There are considerable differences of 'e-maturity[6]' within and between countries, and between schools within countries. In some countries schools have embedded ICT into the curriculum, and demonstrate high levels of effective and appropriate ICT use to support teaching and learning across a wide range of subject areas. In other countries however, schools are in the early phase of ICT adoption, characterised by important enhancements of the learning process, some developments of e-learning (ICT enabled learning), but no profound improvements in learning and teaching.

Such progress as has taken place has been achieved at considerable cost. All EU countries have invested in ICT in schools. Just to give two examples, which will be looked at in this report, Denmark has invested in their national ICT project (ITMF for primary and lower secondary education schools) a sum of €43m over a 4 year period. The UK has spent only for the ICT test bed project[7] an amount of 34 pounds (€49m) over a four year period involving 28 schools. The UK announced in 2004 a further 700m pounds (€1,05bn) in ICT by 2006. What still needs to be examined is the types of return these investments have brought. A number of recent studies begin to provide evidence of the return on investment.[8]

Broadly, three major types of ICT induced studies can be identified since ICT has been introduced in schools in Europe.
1. Many studies have tried to measure ICT integration into education in terms of **infrastructure and access**, such as the availability of computer hardware, the pupil-computer ratio, average number of computers per school and levels of connectivity and bandwidth. The availability of computers in most EU countries is substantial and in nearly all countries (except for the Slovak Republic and Latvia) almost all secondary schools had access to the Internet (OECD 2004).
The recent European Commission report 'Progress towards the Lisbon objectives in education and training: Report based on indicators and benchmarks' (2006) shows that ICT penetration in schools is continuously increasing.

2. A few studies have taken the analysis to the next level: to identify and measure the **use of ICT in educational settings** and also the home use of ICT for educational purposes, not simply its presence. Here the picture is less good. For example, ICT use in schools is still quite low overall, despite the investment: "*In most EU countries ICT is not used very frequently by a majority of students at school… But a substantial number of students had opportunities to use ICT in several ways, probably outside schools"* (Pelgrum, 2004). The picture also becomes complex: with the same availability of technology countries achieve higher or less indices of use (Kollias, Killikis, 2005).

3. Even fewer studies examine a third level of cause and effect: the **impact of investment of ICT** on learning and teaching. As the authors of the most recent study of ICT impact point out: "*it is difficult to establish a causal relationship*

[6] E-maturity is when organisations make strategic and effective use ICT in order to improve educational outcomes.
(see Becta: http://partners.becta.org.uk/index.php?section=bp&catcode=_be_em_02)
[7] High levels of investment were made in 30 schools and colleges in areas of socio-economic deprivation.
[8] Charles Clarke, Secretary of State for Education, at annual BETT conference in 2004.

between computers and educational outcomes" (Machin, 2006). A few studies have attempted to do so, and there is some evidence that investment in ICT impacts on learner performance, on learning and on teaching. However, in the economic literature there are even fewer studies and they all find no evidence of a positive relationship between computers and educational performance. It is probably true to say that, as in many other areas of education policy (and indeed social policy in general); isolating a set of variables or inputs that cause a given result or impact is problematic.

Recent UK studies take this analysis even further and show that only 10-15 percent of schools are e-mature '... *just over one in ten (11%) institutions can reasonably be described as having embedded ICT successfully into teaching and learning'*. At the other end of the e-learning spectrum there seems to be a persistent 13 per cent of institutions who are late adopters[9].

On the other spectrum, there are many theories and studies describing the **profound implications** of ICT for education: education can be transformed using ICT which brings new capabilities and capacities to learning. For example, ICT has the **potential** enabling teachers and students to construct rich multi-sensory, interactive environments with almost unlimited teaching and learning potential.

The UNESCO (2005) study '*Information and Communication Technologies in schools: a handbook for teachers or how ICT Can Create New, Open Learning Environments'*, is one of a number of publications describing how ICT potentially offers numerous advantages and provides opportunities for:

- facilitating learning for children who have different learning styles and abilities, including slow learners, the socially disadvantaged, the mentally and physically handicapped, the talented, and those living in remote rural areas;
- making learning more effective, involving more senses in a multimedia context and more connections in a hypermedia context; and
- providing a broader international context for approaching problems as well as being more sensitive response to local needs.

At the same time, ICT is said to enable teachers to save time and to increase productivity in such activities as:[10]

- preparing and updating daily lessons;
- plans, making hard copy visualisations and handouts for classes, as well as individualised educational plans for slower students and students with disabilities or with special problems;
- presenting visual/oral content materials, tasks, and questions to the audience;
- maintaining grade books;
- compiling a data bank of exam questions;
- online inspection and correction of students' work on their computers; and
- keeping records, chronicles, and archives of all the above-mentioned events and proceedings with fast retrieval and easy access to any entry.

In addition, as ICT becomes more pervasive, computer-based equipment is integrated into every aspect of a school's operation, having thus an impact on the whole school operation and development.

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[9] See Amstrong, D. *et al*. (2004) 'Moving towards e-learning in schools and Fe colleges, Price WaterhouseCoopers, http://www.dfes.gov.uk/research/data/uploadfiles/RR601.pdf

[10] Unesco (2005)

Despite the above cited opportunities ICT can offer in everyday school practice, ICT is also seen as a major driver for change. '*ICT has the potential to act as a force for change in education*' [11] that is, to bring about changes that will affect learners, practitioners as well as the whole institution. The question to be addressed in this report is whether, and most of all, how and by whom the potential of ICT in education is fully exploited in teaching and learning in schools and what barriers remain to the effective deployment of ICT? Evidence of recent impact studies across Europe are analysed to shed light on the issue.

[11] Odile Quintin closing speech, EU e-learning conference, Helsinki, July 2006.

2. Aim and Background of the Review

This study, carried out in the framework of the European Commission's ICT Cluster work, addresses the question of what have been the results or evidence of ICT investments and integration into schools so far, specifically for learning and learners and teaching and teachers. It draws on evidence from a range of recent surveys and research studies measuring the impact of ICT.

The report aims to:

- Establish a comprehensive picture of the evidence of the impact of ICT that is available from national and European studies;
- Give a reference framework for describing impact, looking at approaches and methods currently used in these studies and their suitability;
- Synthesise the main results of these studies for policy makers, education professionals and school practitioners with a major interest in ICT developments and progress made in recent years in this field;
- Provide an overview of impact studies and the areas where impact has been shown;
- Provide a baseline for discussion on the findings with policy makers and other education professionals;
- Highlight barriers of ICT integration in European schools;
- Identify gaps in current research;
- Give policy recommendations on the basis of the evidence available in order to create favourable framework conditions for effective ICT integration as well as future fields of actions at national and European level.

Acknowledgements

The authors would like to thank the members of the ICT Cluster group, chaired by José Pessanha, European Commission DG Education and Culture, for their input and in depth discussion of the report. Additionally, a number of ICT experts in education have given valuable feedback to the report. Our thanks for a critical peer review of the report go in particular to:

Pieter Hogenbirk, Dutch Inspectorate of Education
Anne Gilleran, European Schoolnet
Sanya Gertsen Pedersen, Consultant, Ramboll Management
Bert Jaap van Oel, Dutch Inspectorate of Education
Riina Vuorikari, Research Analyst, European Schoolnet

3. Methodology

The work was undertaken in two stages June-August 2006 and September – November 2006. The first stage was to identify recent relevant initiatives and studies carried out at national and European level related to measuring and demonstrating the impact of ICT. These studies were mainly identified through screening the Insight Country Reports [12] which are in-depth descriptions of national developments in different areas of e-learning policies in schools and compulsory education. [13] The country reports are provided and regularly updated by national ministries and national authorities responsible for education and contain a section under which reference is made to the most recent e-learning studies. The research team selected key research on impact for each country. At the same time it looked at the latest studies carried out by European and international organisations active in the field of e-learning policy and research such as UNESCO, Eurydice, OECD or commissioned studies by the European Commission (DG EAC).

The review focuses on studies investigating the impact of ICT in education in schools in Europe, specifically at those revealing the impact of ICT on learning outcomes and learners and teachers and teaching methodologies in schools.

The selection criteria applied included:

- Provide evidence of ICT impact on learning outcomes and pedagogies;
- Provide evidence on progress made with ICT in schools in learning and teaching;
- Preferably available in English;[14]
- Published since 2002;
- Individual EU member states and European-wide studies;
- Large-and small scale national or European studies;
- Evaluations of impact of government initiatives or interventions in this area; large or small scale, showing significant results within the scope of the review.

Next to results of national and European surveys -the core review studies-, research literature revealing insights into the impact of ICT on a more theoretical complement the picture.

In order to cover the major work on the topic, the research team listed the research reports identified with a total of 25 studies and sent it to members of the ICT cluster group who were requested to refer to any research (preferably in English) relevant to the topic that had not been included. Only three studies were added to the list.

The next stage involved establishing procedures for reviewing the research to ensure a systematic and relevant approach. This was especially important given the high degree of heterogeneity between the various studies in terms of scope, methodology and geographical context. It was therefore agreed that a particular focus would be placed on recent research that has attempted either to 'measure' (quantitative evidence) or to 'assess' (qualitative based evidence) the impact of

[12] http://insight.eun.org
[13] Compulsory education 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.
[14] The authors are aware that the report predominantly included English written literature. A way forward to include more results of national research is shortly discussed in chapter 11.

ICT in terms of learning outcomes and teaching methodologies.[15] Studies that were most relevant to the focus of the review were included regardless of their (positive or negative) findings. Altogether 17 studies were included. These studies represent the 'core part' of this report upon which the findings are based. The authors acknowledge that despite an extensive research, the review does not cover results of specific national research only available in the countries' language. The number of studies to be included in the core review was also limited to 15 to 20 studies. In parallel, the research team has carried out extensive desk research and examined a number of research literature providing significant input to the analysis and the interpretation of findings.

The studies of primary focus of the review were analysed and clustered according to a common structure, which included:

- The aim of the study
- Scope
- Methodology
- Indicators used

Annex 2 gives an overview of the studies concerning these aspects and reveals specific impact areas.

The following specific thematic issues were agreed for examination:

- Impact on learners and learning outcomes
- Impact on teachers and teaching methodologies
- Success factors/barriers for effective ICT use

Chapter 6, 7 and 8 highlight the results of the thematic issues.

In a second stage, between September and November 2006, a draft of the report was reviewed by a number of ICT in education experts. Additionally, the report was presented during an ICT cluster meeting (15 November 2006) and extensively discussed by its members. Apart from a general feedback to the report the ICT cluster gave concrete inputs to the Recommendations, which are presented in Chapter 11.

Although this report is extensive, it is not a complete research review of all ICT impact studies and surveys across Europe. Moreover, countries' contribution to the report is not balanced. Some countries have undertaken extensive research in the field of ICT impact (e.g. United Kingdom); others concentrate on the impact of ICT on education applying for the first time a broader comparative approach (e.g. Nordic Countries). Finally, other countries focus only on quantitative stocktaking of ICT infrastructures in schools, or the results of research is simply difficult to access because of language and fragmentation of research (e.g. Mediterranean countries, New Member States, France and German speaking countries).

An overview and a short description of the studies examined in this report is provided in chapter 4 whereas chapter 5 addresses the concept of impact.

[15] Most studies under review, however, combine the two methodologies (qualitative and quantitative) and have a wider scope. They also look at the impact of ICT in a number of other areas, e.g. school development, home school cooperation just to mention a few.

4. Overview of studies examined

The following section gives a brief overview of the 15 core studies under review structured by country.

Broadly, there can be made a distinction between studies that directly address the concept of impact, and studies that address the concept of impact more indirectly by evaluating various objectives of a specific intervention or national programme. On a third level, some studies look at progress and changes made with ICT in education over time. Next to results of national and European studies -the core review studies-, research literature revealing insights into the impact of ICT on a more theoretical level have been analysed and included in the report.

The following types of studies have been included in the core analysis:

- Large scale impact studies
- Evaluations of large scale policy programmes or initiatives
- National Inspection reports analysing progress over time
- Evaluation of specific national interventions and projects, large and small scale
- National research reviews
- International and European comparisons
- European case studies

4.1. National studies

United Kingdom [16]

In terms of evidence of ICT impact UK studies provide the richest picture. Numerous amounts of studies have been carried out in recent years to evaluate the impact of ICT on a regular basis and are mostly published by BECTA, the British Educational Communications and Technology Agency, in its research area. These include evaluations of government initiatives in the field of ICT, evidence of the benefits of emerging technologies and ICT impact on education.

ImpaCT2: The Impact of ICTs on pupil learning and attainment (Harrison, C. et al., 2002) and ***ImpaCT2: Learning at Home and School: Case Studies (Comber, C. et al., 2002)***

One of the most comprehensive investigations into the impact of ICT on educational attainment so far conducted on the in the UK is the Impact 2 study: The Impact of ICTs on pupil learning and attainment (Becta 2002). The results of the first strand of the research project, analysing the relationship between pupil use of ICT and their performance in national tests and GCSE's (General Certificates of Secondary Education), is given special attention in this report showing ICT impact on attainment. The project ran from 1999 until 2002 and involved 60 schools in England. Furthermore, strand 3 of the project established a qualitative evidence base that supplements findings from strand 1 and 2 by including a series of linked case studies employing a range of research methods such as observations, interviews and, video diaries. This strand focused on

[16] More information regarding Key Stages, National Curriculum levels and National Tests can be found the National Curriculum on-line web site (www.nc.uk.net) and on the DfES Parents' web site (www.dfes.gov.uk/parents), or in the Insight country report UK:http://insight.eun.org

learning and teaching environments, learning and teaching styles and the impact of networked technologies on the perception of teachers, managers, pupils and parents. Results of this are specifically relevant for the chapter on teaching methodologies.

New technologies in schools: Is there a pay off? (Machin et al., 2006)
This paper, which is quite distinct from the educational studies looked at in this report, investigates from an economic point of view the impact of ICT investment on educational outcomes, more specifically whether the changes in ICT investment in the UK over the period from 1999 to 2003 had any causal impact on changes in educational outcomes. The study aims to make, in a quasi experimental setting, the causal link between a change in rules governing ICT investment in different regions of England leading to changes in ICT investment and subsequently changed educational outcomes.

ICT Test Bed Evaluation (Underwood, J et al., 2006)
A major UK project set up by the Department for Education and Skills (DfES) is the ICT test bed project during which high levels of investments of ICT were made in schools and colleges in areas of socio- economic deprivation. The project evaluation offers a longitudinal view of change in 30 schools and colleges over a four year period 2002-2006. It looks at the relationship between ICT, institution level developments, classroom practices and learner outcomes.

Additionally, a number of studies have been carried out in assessing specific technologies such as the impact of broadband in schools (Underwood, 2005) or the impact of use of interactive whiteboards in schools (Higgins, 2005)[17].

Impact of Use of Interactive Whiteboards (IWB's) "Embedding ICT in the Literacy and Numeracy Strategies" (Higgins et al., 2005)
The study on the use of interactive whiteboards is an evaluation of the "Embedding ICT in the Literacy and Numeracy Strategies" pilot project running from 2002 to 2004 in six Local Education Authorities (LEA' s) in England where interactive whiteboards (IWB' s) were installed in year 5 and year 6 classes. [18] The research project aimed to evaluate a number of areas: impact on pupil attainment, changes in classroom interaction, the use of IWBs for literacy and mathematics, teachers' perceptions and pupils' views. In a total of 184 classroom observations the focus was on classroom interaction, differences between lessons where teachers did and did not use IWB' s for literacy and mathematics and on any changes in patterns of interaction one year later.

Impact of Broadband in Schools (Underwood et al. 2005)
The broadband report looked at the current state of knowledge of the impact of broadband technologies on the educational process, more specifically on the standard performance data. As of June 2005, 81 per cent of maintained schools in England had a broadband connection.

The Becta Review 2005 and 2006
The Becta Review 2005 and 2006 bring together findings from recent large-scale surveys and research studies with the aim of assessing the progress of ICT in

[17] Several other studies on emerging technologies such as the use of videoconferencing, laptops or games or handheld technologies such as PDA's have been commissioned but are not included in this report. For a full list of studies mostly commissioned by Becta see:
http://partners.becta.org.uk/index.php?section=rh&catcode=_re_rp_ap_03
[18] Year 5 = age 9 by the end of the year,
Year 6 = aged 10 by the end of the year (i.e. final year of primary school)

schools and colleges at national level. The Reviews have been published in 2005 and 2006 and provide an overview of technology provision, practice and impact in the schools and learning and skills sectors.

From the **Nordic countries** the latest national evaluations from Denmark and Norway have been included. [19]

Denmark

ITMF- ICT Media and Primary and Lower secondary education schools, (Ramboll Management, 2005)

In Denmark the large scale national ICT project ITMF has been evaluated. The project ran from 2001 to 2004 with the aim to strengthen the pedagogical use of ICT and to make ICT an active incentive in the every day life of schools via development and best practice projects. The project included 32% of all primary and secondary schools in Denmark. [20] The evaluation (Ramboll Management, 2005) specifically looked at overall changes in school practice and at how far the project objectives had been achieved. The project goals included:

1) Supporting reading, writing and language skills of the students;
2) Strengthening students´ general ICT and media skills;
3) Strengthening the content of subjects, including themes, concepts and methods;
4) Supporting interdisciplinary work;
5) Encouraging new learning methods;
6) Making schools more inclusive and
7) Exchanging good practice.

Norway

PILOT Project: Innovation in Learning, Organisation and Technology (ITU, 2004)

In Norway the largest and most comprehensive initiative supporting the educational use of ICT called PILOT has been evaluated by ITU and the University of Oslo. The project ran from 1999 to 2003 and involved 120 schools spread across the country with nine municipalities involved. The overall project goal was to motivate schools to develop the educational and organisational potential of learning with ICT. The study did not primarily focus on the effect of ICT on student performance but on evaluative measurements and quality improvements. It gives insights into the changes teachers, school leaders and students ascribe to ICT in schools. The different municipalities involved also focused on a specific area of ICT use, such as learning networks or digital portfolios.

The Netherlands

8 years of ICT in schools (ICT Monitor, 2005)

The ICT Monitor "8 years of ICT in schools", analyses developments in the field of ICT in schools on the basis of yearly ICT monitors in the Netherlands since 2000/2001. The school inspectorate has been given the task to identify the output of the ICT policy.
The themes included in the analysis are:

- ICT in the teaching and learning process;
- ICT infrastructure and facilities;
- Policy and ICT;
- Skills and notions;

[19] No recent large scale national evaluations have been found from Iceland or Finland and the Swedish ITiS evaluation dating from 2002 has not been included.
[20] Overall number of schools in Denmark: 1719

- ICT in management and education support processes;
- Developments of pressure points following the introduction of ICT.

Estonia

Tiger in Focus (Toots, et al 2004)

The most comprehensive and accessible national ICT survey within the central and Eastern European context is the "Tiger in Focus Study" from Estonia: a longitudinal survey on ICT in Estonian schools 2000-2004. The study looks and the progress that has been made with ICT in Estonian schools. It focuses on the use of ICT as a tool for learning within a specific subject domain, assesses students' and teachers' ICT skills and self perceived competences. The study uses a set of impact indicators.

4.2. European / International studies

E-learning Nordic 2006 (Ramboll Management 2006)

The elearning Nordic study is the first inter Nordic study specifically concentrating on the impact of ICT on education in Finland, Sweden, Norway and Denmark. More than 8000 people in 224 primary and secondary schools participated in the survey. The survey methodology centred on asking key participants about the impact of ICT based on their experience. The results therefore show the "perceived impact" of ICT. The impact of ICT was studied in three key areas of education: 1. Pupil performance, 2. Teaching and learning processes, 3. Knowledge sharing, communication and home-school cooperation.

ERNIST ICT school portraits (European Schoolnet, 2004)

The Inspectorate set up a large scale ICT monitoring programme to describe and analyse schools that use ICT applications effectively and as a means of developing ICT evaluation standards, namely the ICT school portraits. [21]

During the ERNIST project 20 innovative schools have been portrayed by six European inspectorates, showing how ICT affects pupils, teachers, the school organisation and the cooperation with others. The range of portraits are not representative for their countries, the intrinsic value of the case study is to have an in depth look at the change processes taking place in schools and add to the existing quantitative and survey data. However, a clear set of characteristics and issues emerged from the portraits, shared by all the schools. This report will refer to the evidence revealed in the learning and teaching processes.

Benchmarking Access and Use of ICT in European Schools (Empirica, 2006)

The study was carried out in the framework of the European Commission's monitoring and benchmarking process and results will feed into the Information society i2010 programme. It is a follow up of the earlier benchmarking exercise for eEurope 2002 and involved two surveys: a head teacher survey of more than 10,000 head teachers to obtain information on the schools and a survey of more than 20,000 classroom teachers to focus on their use of ICT for educational purposes. The survey was carried out in spring 2006 in all 25 EU Member States, Norway, and Iceland. It includes information on ICT equipment and internet in schools, their use in class, comparisons of the situation in 2001 and 2006, attitudes on ICT use by teachers, results on access, competence and motivation for using ICT in school and the ICT readiness of teachers. Concise Country Briefs for each of the 27 countries are provided.

[21] www.ICT-onderwijsmonitor.nl (publications) and http://insight.eun.org (school innovations)

Results relating to the current use of ICT in schools and the impact of ICT on teachers' practice are emphasised in the review.

Are students ready for a technology rich world? (OECD, 2004)

In the last two years emphasis has been put into analysing the PISA (2000 and 2003) results. The OECD study "Are students ready for a technology rich world?: What PISA studies tell us explores data collected by PISA in 2003. The report looks at how often and where students use computers, duration of use, which tasks they perform on computers and how confident they are in using ICT. All these characteristics are then compared to how well students perform in mathematics, the main area of student performance examined in PISA 2003. PISA 2003 was conducted in 41 European countries assessing performance data of 15 year old students in mathematics, reading and science and cross curricular problem solving skills.

How boys and girls are finding their way with ICT? (Eurydice, 2005)

In its latest ICT publication Eurydice has analysed PISA 2003 data according to gender specific use of ICT. Indicators looked at are frequency of use, where computers are used, in which context and for what type of activities and self assessment.

Key data on ICT in schools in Europe (Eurydice 2004)

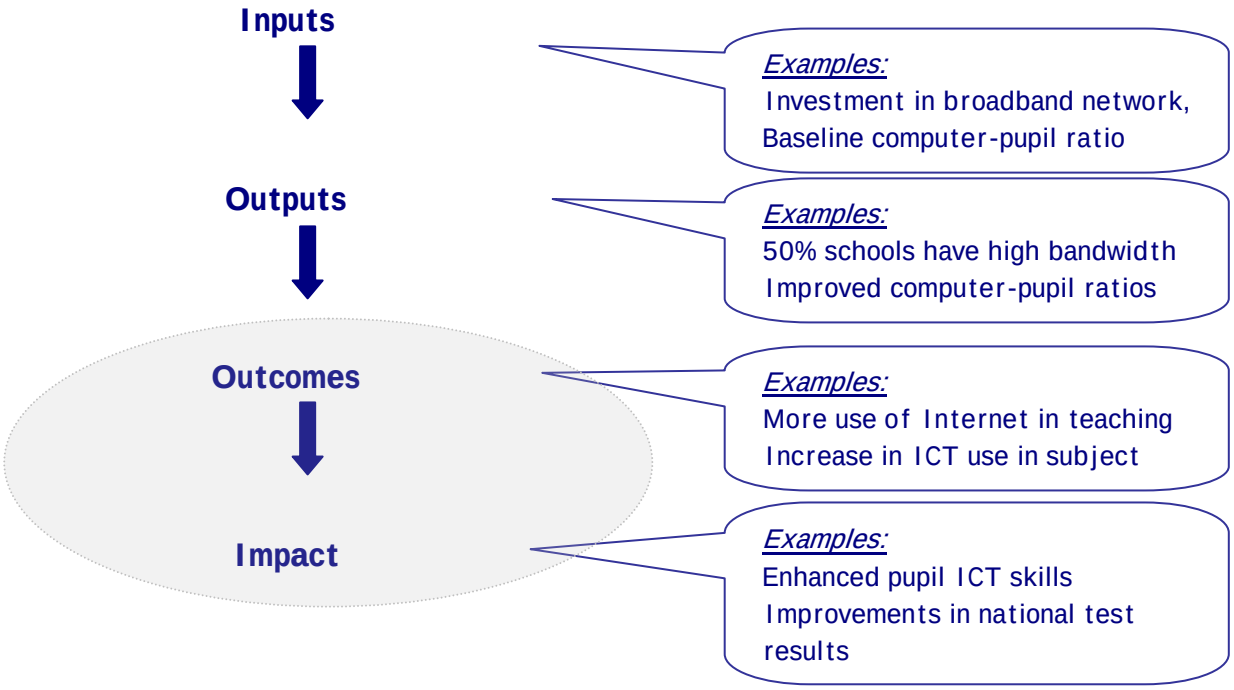
Key data on ICT in schools in Europe gives a number of indicators on ICT in schools concerning the organisation of ICT teaching, but the study is limited with respect to indicators concerning the impact of ICT on teaching methods, the quality of education or the competence of pupils and teachers.

5. Description of Impact

Only three of the 17 reports [22] consider the concept of 'impact' explicitly: The approach taken in ImpaCT2, The Impact of Information and Communications Technologies on Pupil learning and attainment (BECTA, 2002) and the elearning Nordic study (Ramboll Management, 2006) shall be discussed in the following chapter. They differ in their approach.

In the Becta study[23] 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.

Description of impact (Becta)



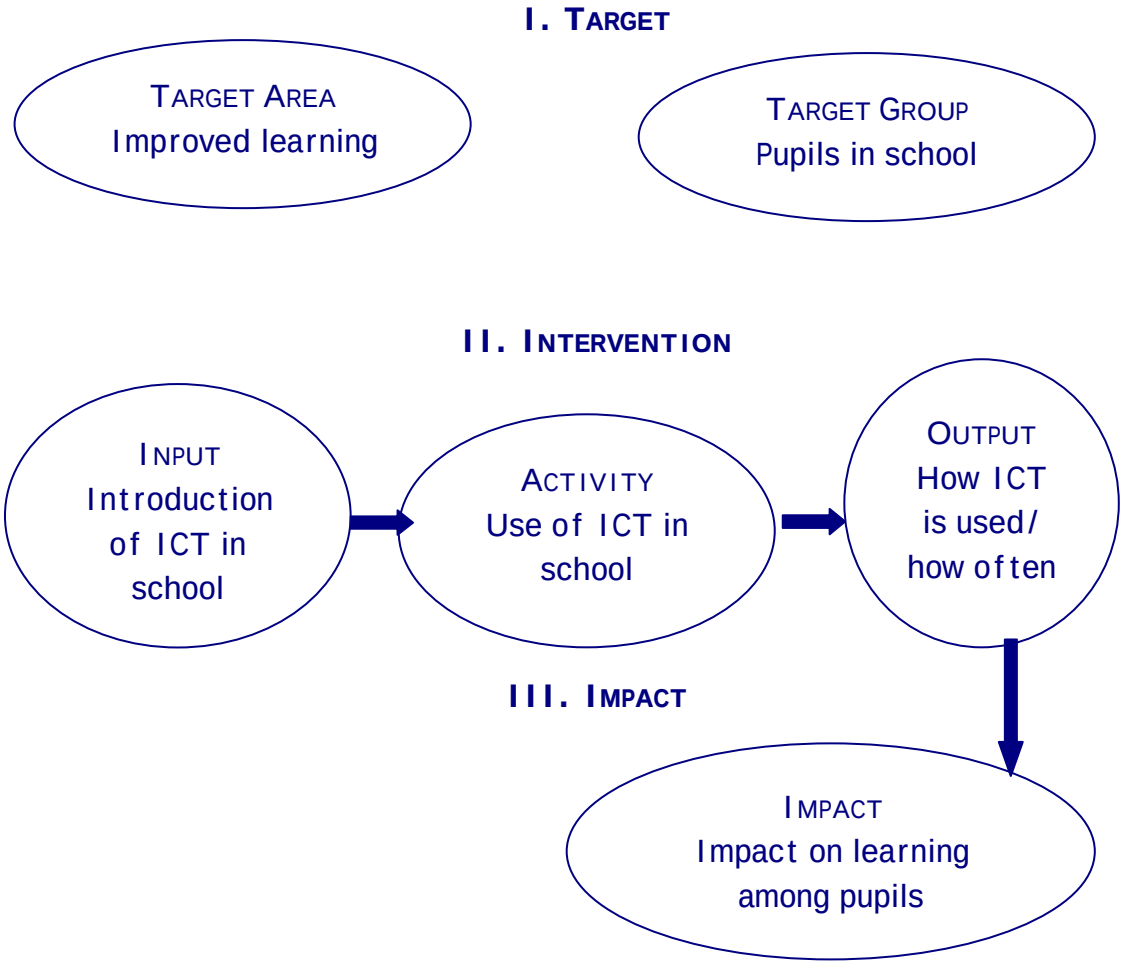
The intervention has four dimensions: input, output, outcome and impact. At the beginning of the process there are **inputs**, e.g. provision of broadband, funding for schools to buy laptops. For gathering evidence of impact, baseline input data is also required, e.g. current pupil:computer ratios. These inputs lead to direct quantifiable **outputs**, for example the percentage of schools with broadband connections or improved pupil:computer ratios. **Outcomes** are the broader results achieved by the ICT investments, such as greater use of ICT in teaching. **Impact** is the overall achievement of the intervention on the educational system and can be described by a variety of qualitative indicators such as enhanced pupil ICT skills or improvements in national test results.

[22] Machin et al, 2006 takes an economic approach to impact which is not being further analysed here.
[23] Dr. Vanessa Pittard, Phil Bannsiter, Evidence and Evaluation, (BECTA), Presentation given at elearning conference, Helsinki, July 2006.

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, as the following table shows.

Description of impact (E-learning Nordic 2006)



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'.

The **intervention** has three elements: input, activity and output. The **input** is introducing ICT into schools; as the study notes: "The use of ICT in schools can be therefore understood as a deliberate intervention, or intended change, in the way in which teaching and learning take place". **Activities** carried out, e.g. measures to increase the use of ICT in schools, lead to **outputs,** the direct and more quantifiable results of activities, such as the number of computers purchased or numbers of lessons using ICT.

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.

Regardless of target, conditions on the intervention side must be made explicit in order to assess impact. These conditions result in impact through various processes. A causal link between one factor (e.g. the use of a specific tool) and the wider impact or an 'end-point' outcome (e.g. improved learning outcomes) is so difficult to prove with many interrelating and difficult to control variables (students' attitude, teaching processes, etc.) to be considered. It is easier to measure the more direct links between input (more internet connections) and outputs / outcomes such as the use of the internet. Such crucial issues may go some way towards explaining why there are few explicitly impact-oriented studies and brings out a tension underlying this study: how can relatively simple input and output measures be applied to complex social interactions taking place in schools? In the health service for example it is possible to determine the effect of a given medical intervention, to determine the cost of such an intervention and subsequently to assess, generalise and direct funding to those who adopt such best practice. Yet, without evidence of pay off, it is difficult to convince decision-makers, politicians, treasury officials and voters that ICT in schools is worthwhile.

The following chapter aims to present the evidence from these two and the other thirteen studies as regards learning outcomes. However, measuring ICT impact on learning outcomes is only one area of potential impact. Much depends much on how ICT is used and so it is important to consider the factors that prepare the ground for improved learning and consequently lead to better learning outcomes. A second crucial area of ICT impact is therefore the underlying teaching conditions that promote ICT enhanced learning. Whether teaching methodologies have changed through ICT and what methods allow optimum use of ICT in learning is the major focus of chapter 7.

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.

Impact is the **end-point of an intervention** involving input, process, output and outcome. Isolating the variable that caused the impact is problematic in education.

6. Impact on learning outcomes and learners

As with ICT more generally, direct causal impacts are not always easily identifiable. Furthermore, drawing clear conclusions on the impact of ICT from the range of research evidence and studies can be problematic. There are a number of factors that limit effective comparisons, such as differences in sample sizes, methodologies and effects, not to mention many differences between education systems in different countries. Notwithstanding these reservations, a number of proven effects of ICT in terms of learning outcomes emerge. This chapter examines the impact of ICT on 'learning outcomes', first on pupil attainment, and secondly wider benefits for learners such as motivation, skills and competences.

6.1. ICT and pupil attainment

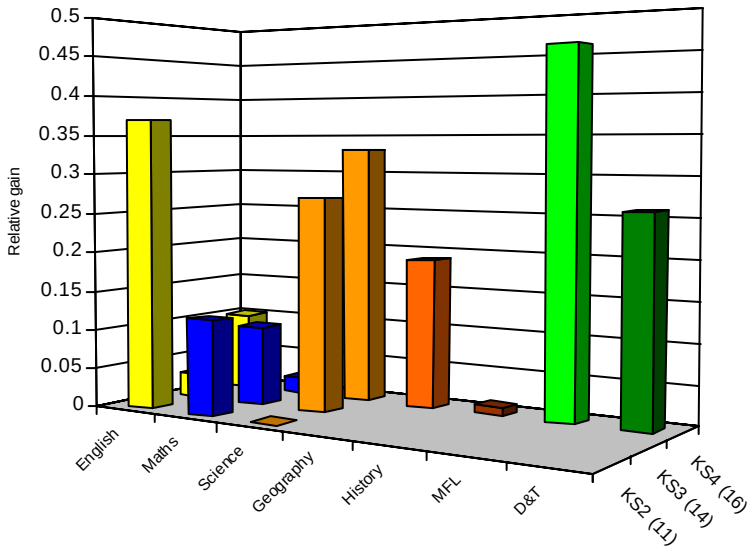
When considering the impact of ICT in education there tends to be a focus on whether and to what extent, ICT can raise pupil attainment.[24] Yet, it is often difficult to establish hard evidence of improved pupil attainment as a result of using ICT. Isolating the impact of ICT from all other factors that can affect achievement can be problematic. However, positive relationships between ICT use and improvement in subject-related learning have been found in several subject areas.

A research project conducted by Becta (the British Educational Communication and Technology Agency) on behalf of the DfES investigated the effects of ICT on educational attainment, based on evidence gathered from 60 schools in England. This project (ImpaCT2 project), considered as one of the most comprehensive investigations into the impact of ICT on educational achievement so far conducted in the UK, analysed the relationship between the pupils' performance in National Tests and GCSEs[25] and their reported use of ICT at three age levels (11, 14, 16), in English, Maths and Science (and in additional subjects at the age 16).

The study found evidence of a statistically significant positive association between ICT and higher achievement, most notably in national tests for English at Key Stage 2 (age 11), in National Tests for science at Key Stage 3 (age 14), and in GCSE exams for science and design and technology at Key Stage 4 (age 16). On the basis of these findings one can say that high ICT use in English (i.e. mother tongue) at ages 7-11 (Key Stage 2) and in science at ages 11 to 14 (Key Stage 3) can help to raise performance by the equivalent of 0.16 and 0.21 respectively of a National Curriculum performance level. Similarly, high ICT use in science and in design and technology at ages 14-16 (Key Stage 4) can contribute to an increase of performance by 0.56 and 0.41 of a GCSE grade respectively. In other words, **ICT use between ages 7 and 16 can result in significant relative gains in English, science and design and technology.** The graph below depicts the positive impact of ICT on certain subjects.

[25] At the end of Key Stages 1 (up to age 7), 2 (up to age 11) and 3 (up to age 14) children take national tests and tasks (popularly called SATs). At the end of Key Stage 4 (up to age 16), they will take the General Certificate of Secondary Education (GCSEs) examinations.
The difference between attainment and achievement is not always clear for non English speakers. Attainment can be described as the grade/level achieved (ie grade B at GCSE) Achievement is the value added ie if the baseline data suggested a grade A should be achieved, then a grade B would represent good attainment but low achievement. So achievement is measured against prior attainment. (taken from Times' educational supplement)

Relative gains in national tests (KS2, KS3, KS4)



A second UK project that investigates how the sustained and embedded use of ICT in learning spaces can improve learner outcomes is the Test Bed project, conducted from 2002 to 2006. The evaluation of the project confirms that technology deployment and use may lead to an improvement in test performance relative to 'benchmark' comparators. The rate of improvement in Test Bed schools and LAs (Local Authorities) for some tests was higher than that for benchmark comparator LAs. In English Key stage 3, Test Bed LAs improved by 4.68% between 2002 and 2004, while comparator LAs improved by 4.09. Test Bed schools in key stage 3 mathematics tests in 2004 improved significantly compared to their performance between 2002 and 2003. In addition the number of secondary pupils achieving A to C GCSE grades had significantly improved over the course of the project.

The Test Bed Project shows that e-maturity[26] makes a difference. **Schools with higher levels of e-maturity demonstrate a more rapid increase in performance scores than those with lower levels**. Just one year after new equipment had been installed in the ICT Test Bed schools there was improved attainment. Thus, from this report, it is possible to quantify the effect of an ICT investment and to show the cost of achieving an improved outcome. It should be noted, however that the evaluation report presents only preliminary findings from the ICT Test Bed project: test score data are only available up to 2004 whereas the 2005 and 2006 results will be included in the final evaluation report in early 2007. Thus, we cannot be sure of whether this improvement has been sustained.

The recent UK study 'New Technology in schools: is there a pay off?' (2006), also finds evidence for a causal link between a substantial increase in ICT investment and a rise in educational performance in primary schools. This is most evident in the teaching of English and Science, yet no positive impact is observed for Mathematics.

[26]see Becta: http://partners.becta.org.uk/index.php?section=bp&catcode=_be_em_02

As far as the deployment of specific technologies is concerned, the 'Impact of Broadband in schools' (Nottingham Trent University on behalf of Becta [27]) underlines the crucial importance and impact of broadband connections, and clearly demonstrates the benefits and advantages that this investment can bring to schools. More specifically, in the year immediately **following the installation of broadband, significant improvements took place in pupils' performance on national tests taken at age 16**. However, this finding should be treated with caution due to small sample size.

With regard to interactive whiteboards (IWBs), the DfES commissioned the University of Newcastle in 2002 to conduct a two-year research study to evaluate the 'Embedding ICT in the Literacy and Numeracy Strategies' pilot project[28]. The evaluation showed that **one year after the introduction of interactive whiteboards, pupils' performance improved more in national literacy, mathematics and science tests compared to pupils in other schools**. Yet this small though statistically important gain was not sustained into the second year of implementation. There was also some evidence that the **use of interactive whiteboards improves the performance of low-achieving pupils in English and the overall impact was greatest on writing**. However, no other statistically significant attainment effects were picked up. Therefore, a question that remained unclear was as to whether improvements in pupil attainment during the first year after the introduction of whiteboards were due to good (or rejuvenated?) teaching as some teachers have claimed rather than technology alone.

Echoing these findings, the 2006 OECD study *'Are pupils ready for a technology-rich world?: what PISA studies tell us*' further indicates that **there is an association between the length of time students have been using computers and their performance in PISA mathematics**. By comparing computer access and frequency of usage to students' performance in mathematics[29], the study concluded that the longer pupils have used computers the better they performed (up to a certain point). For example, pupils who have used computers for less than one year score well below the OECD average, performing only the simplest mathematics tasks, whereas pupils with more than a five-year experience score well above the OECD average. Yet, the PISA data do not demonstrate causation; they only point to important interrelationships worth closer investigation.

This is also true for the studies examined previously. Indeed, the outcomes of these studies do not prove the existence of a direct link between the use of ICT and student performance. As learning is mediated through the learning environment and ICT is only one element of that environment, it is impossible to entirely remove the effects of the other elements of the learning environment and suggest a consistent relationship between ICT use and attainment. However, the weight of evidence clearly shows that there can be a significant positive impact using ICT.

The UK studies focus mainly on the 'measured' impact of ICT in terms of pupil attainment. However, a number of interesting studies concentrate on the

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[27]The DfES have stipulated that all schools should be connected to a 2Mb, symmetrical broadband internet connection before the end of 2006; As of June 2005, 81% of maintained schools in England had a broadband connection (78% of primary and 99% of secondary schools).These figures are rising as broadband deployments continue apace.

[28] This project involved the installation and use of interactive whiteboards (IWBs) in Year 5 and Year 6 classes in 12-15 schools in each of six selected LEAs.

[29] Mathematics is the main area of student performance examined in PISA 2003

'perceived impacts' of ICT. This is the case of the 'e-learning Nordic 2006' conducted in Finland, Denmark, Norway and Sweden which presents teachers', pupils' and parents' views about the consequences of using ICT in schools[30].

The study shows that **pupils, teachers and parents consider that ICT has a positive impact on pupils' learning**. In the question '*does ICT improve pupil performance'*, two in three teachers report that there has been **an improvement in their pupils' subject-related performance and their basic skills** (calculation, reading and writing). In addition, teachers consider that **academically strong students benefit more from ICT use**. Only the Finnish teachers' experiences are less positive and many think that ICT has no impact.

With regard to writing skills, most teachers report that they experience a moderate or high degree of positive impact. This is also confirmed by the pupils themselves as well as their parents. Yet, the pupils appear more critical than the adults and in some countries (Finland, Denmark) their responses are divided. Only in Norway are students clearly convinced that they learn more when they use ICT.

This corresponds with the findings of the Pilot project (Project Innovation in learning, Organisation, and Technology), Norway's largest and most comprehensive initiative supporting the educational use of ICT in schools. In this project, 52% of students asserted that **ICT increased their performance in school subjects**, a figure confirmed by the overwhelming majority of teachers (83%). This study shows that both reading and writing levels were higher than what was typical for students who did not use computers and observations verify that students use ICT more frequently and in a more advanced manner – away from entertainment sites and toward educational resources. The qualitative analysis also shows that text production increased, leading to increased competence in writing, argumentation and reflection skills.

In line with these observations are the outcomes of the ICT Monitor study 'Eight Years of ICT in schools' issued by the Dutch Ministry of Education Culture and Science. According to this report which analyses the developments in the field of ICT in Dutch schools in the past eight years (since 1997) on the basis of yearly ICT Monitors, **teachers are becoming more and more convinced that the educational achievements of pupils improves through the use of ICT**. Around 60%-70% of teachers in primary and secondary education believed this in 2003-2004, as opposed to only 22% in 97/98. The sharpest increase was seen in 00/01 with already 51 % of teachers being convinced.

The ERNIST school portraits (EUN, 2004) also show clear perceptions by inspectors, pupils, teachers and school leaders that ICT contributed to better teaching and learning. However, the schools were selected according to early adopters both in terms of innovation and technology.

Another study of particular interest is the evaluation of the Danish ITMF project- a large scale national project with the aim to strengthen the pedagogical use of ICT and other media in education. The outcomes of the evaluation show that most of the goals were principally achieved by the project[31]. However, the idea behind the project to support the use of ICT and media consciously as a tool for learning

[30] Data collection in the study was based explorative interviews, an internet-based survey conducted among 224 Nordic schools and in which 8000 persons have participated and twelve case studies.

[31] see Kessel (2005)

basic skills (reading, writing, arithmetic and language skills), only penetrated with regard to a minority of the teachers. For instance, only 31 % of teachers believed that the aim of ICT use is to support the pupils' writing skills, in spite of the fact that word-processing is used in education by 72% of teachers.

Overall, evidence from the studies reviewed shows that attainment improves as a result of embedding ICT into teaching and learning. However, it was a common observation that there is a difficulty to quantify the *extent* of the improvement or the *causal chain* that links e-learning to improved outcomes. Inferring a *causal relationship* between ICT and pupil achievements from simple correlations can be misleading. It has to be considered that many unobserved factors may influence better learning results in national tests. According to the study '*Innovative Learning Environments for School*'[32] 'many variables and not ICT alone influence a learning situation or a learning environment'. Factors such as local school strategies, the school management's style, and parents' attitude *combined* with the strategic use of ICT may lead to a paradigm shift in learning. It can be assumed, that schools with more motivated teachers and head teachers are more likely to adopt ICT and to produce better attainments.[33] If these factors are not taken into consideration, the findings might be deceptive. Isolating the impact of just one factor, such as ICT, therefore requires a well-considered approach.

Furthermore, although assessing changes in learning outcomes and processes are important approaches to evaluating educational impact, it is also important to recognize that characteristics of the students, the technology, and the interaction between students and technology may influence its effectiveness. Moreover, socio –economic context has been proven a decisive variable determining student outcomes.[34] Characteristics of the learner include motivation, ability, and prior knowledge of (or experience in) the domain. In particular, the background knowledge of the learner has been repeatedly in the studies identified as a critical predictor in learning performance. Differences in students' prior knowledge or experiences have been found to change the usefulness of different resources and to result in different learning outcomes. Finding ways to assess and to account for student experience or knowledge is crucial to developing valid assessment of educational technology.

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. Wider areas of ICT impact like student attitudes and motivation and collaboration are also important and these will now be examined.

6.2. Impact on learners

Motivation and skills

A high proportion of studies of the impact of ICT do not focus on student attainment as measured by attainment tests, but rather on what might be called secondary or indirect variables such as motivation, concentration, cognitive processing, reading comprehension and critical thinking. Indeed, the

[32] The study is based on six best practice case studies in Denmark, Great Britain (Scotland), Netherlands, Spain (Catalonia) and Sweden

33 Policy and Innovation in Education: 'Leadership', European Schoolnet. 2005. http://insight.eun.org/ww/en/pub/insight/thematic_dossiers/leadership.htm

[34] See for example PISA (2003)

overwhelming majority of the studies reviewed in this report confirm ICT's positive effects on those variables.

On a wider European level, the Eurobarometer Benchmarking survey reveals that the vast majority of European teachers see the advantages of ICT use in school and especially for letting pupils do exercises and practice (80%). A very high 86% state that pupils are more motivated and attentive when computers and the Internet are used in class. However, in some countries there is a substantial number of teachers (overall 1/5 of European teachers), who deny that there is much of a pedagogical advantage of computer use in class (Empirica, 2006).

The case studies examined in Strand 3 of the ImpaCT2 study, indicate that relatively few teachers in the sample offered direct evidence of ICT's impact on attainment, preferring instead to concentrate on its **positive effects on behaviour, motivation, communication and process skills**. The motivating effect of ICT is a common factor in teachers' comments and this is most often linked to a shift in the attitude of pupils and a greater involvement in learning activities: '*The children …are completely committed to doing that work, finishing that task … you can certainly see the motivation. They will all want to go on the computer and the work they produce is far superior, and not just in terms of presentation … they have more time to consider the consequences of what they are learning'* (Year 6 teacher and literacy co-ordinator, Westbrook Primary School).

The pilot evaluation of six local education authorities on the impact of the use of interactive whiteboards in literacy and mathematics lessons in primary schools[35] found that teachers and pupils were positive about this technology, with reports of increased motivation of learners. The evaluation shows that **multimedia and interactive content on interactive whiteboards is engaging and motivating, particularly for primary pupils, and that students pay more attention during lessons** thanks to the stimulating nature of the presentation. The above results are also supported by the results from other UK studies, such as the evaluation of the ICT Test Bed Project, and study on '*the Motivational Effect of ICT on Pupils'* commissioned by the DfES which confirm that **ICT has a strong motivational effect** and is not just an attention grabbing factor (although it does that too).

The e-learning Nordic 2006 study also places a strong emphasis on ICT impact on pupils' motivation, engagement and creativity. According to the teachers, pupils participate more actively when ICT is used. Motivation as well as dialogue and collaboration between students are greater especially when they use ICT to create a physical product, for project or group work. The pupils themselves consider that they pay more attention during class and this is especially the case for pupils in the 5th grade. ICT is seen as increasing pupils' confidence and motivation by making school work more enjoyable, considered as fun and not as regular education. In other words, pupils' attitudes and involvement in the learning activities change.

More involvement and increased effectiveness of learning is also a key impact of ICT identified by the ERNIST ICT school portraits. ICT also helps students to reflect on what and how they have learnt and is thus a catalyst for reflection.

[35] 'Embedding ICT in the Literacy and Numeracy Strategies' pilot project

Independent learning

The fact that ICT enhances a more student-centred learning approach is often cited as among its most important benefits. As felt by the majority of teachers involved in the e-learning Nordic 2006 study, **ICT allows for greater differentiation (especially in primary schools), with programmes tailored to individual pupils' needs**. In other words, ICT provides teachers with the opportunity to provide various learning tasks within the same classroom for the benefit of the individual pupils.

The pupils themselves find that they do assignments more on their own way when using a computer and their parents consider that they solve assignments more at their own level. According to the teachers, pupils work more in cohesion with their own learning preferences, resulting in a favourable impact on both academically strong and weak students (60% of the teachers find that there is a positive impact on both groups and hardly any (1-3%) find that there is a negative impact on the two groups).

Pupils with special needs or behavioural difficulties gain in different ways from the use of ICT: ICT supports their motivation and concentration and teachers become more aware of pupils' needs and problems. Evidence provided from a primary school in Norway shows that by sitting next to the pupil working on the computer, the teacher gathers knowledge about the specific challenges for the individual pupil.

In addition, as far as students with different ethnic backgrounds are concerned, the data reveal that the use of ICT and ICT competences had increased in the participating schools together with the pupils' motivation, joy of learning and reading skills. Pupils with other native languages in Sweden, Denmark and Norway, are less likely to have a computer at home, therefore **ICT use at schools is a factor that helps to minimise the social divide by smoothing out the digital divide.**

Schools participating in the Norwegian PILOT project report that **students assume greater responsibility for their own learning when they use ICT, working more independently and effectively**: '*students receive more individualised tasks and greater insight into teachers' aims, and are able to work at their own tempo with tasks appropriate for their level of study'*. In addition they consider that **ICT offers assignments better suited for their individual needs and makes it easier to organize their own learning, through the use of, for example, digital portfolios**. Diverse learning situations equip students with a range of skills and work techniques; they develop confidence in their own capacity to learn that eventually enables them to perform better in their subjects.

Teamwork

In Netherlands, the number of teachers who consider that the use of ICT stimulates collaboration has doubled (Eight Years of ICT in schools) whereas Nordic teachers feel that dialogue and **teamwork between students is greater when they use ICT for project work**. Teachers involved in the ImpaCT2, Strand 3 study perceived positive effects on behaviour, communication and process skills amongst pupils as a result of the use of ICT. The potential of collaborative work around computers was a frequently observed feature of the use of ICT whether this took place in a 'suite' environment or around a single stand-alone computer. When every pupil in a class was able to work individually, an *'informal kind of peer tutoring'* was noticed. Yet researchers did not come across many examples of learning activities which required collaboration for their

completion, and many of the tasks which teachers called collaborative merely involved pupils working alongside one another, rather than jointly addressing a problem.

This last observation leads us to conclude that 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: *'Benefiting from ICT's potential does not just come by plugging in the computer and continuing with the same teaching styles'*.[36] The question of whether there has been a change in teaching practices will be addressed in chapter 7 along with the more direct effects of ICT on teachers themselves.

[36] Ramboll (2006)

6.3. Research methods to reveal impact of ICT on learning outcomes

Looking at the studies reviewed, only a few of them (ImpaCT2, ICT Test Bed, Impact of Interactive Whiteboards, Impact of Broadband in schools, OECD) 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.

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'*[37]. 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 in depth case studies.

To sum up, each quantitative approach should be augmented with more in depth qualitative data, and the way round to have a sufficient evidence base.

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[37] 'The new Oxford Dictionary of English' (1998) Clarendon Press: Oxford

To summarise

Six studies provide ***quantitative*** **evidence** that ICT can impact on **learning outcomes** based on analyzing the statistical relationship between student's results in exams or tests and ICT use:

- ICT impacts positively on educational performance in primary schools, particular in English and less so on science and not in mathematics (Machin, 2006).
- ICT use between ages 7 and 16 can result in significant relative gains in English, science and design and technology (Harrison, 2002).
- Following the installation of broadband, significant improvements take place in pupils' performance on national tests taken at age 16 (Underwood, 2005).
- After the introduction of interactive whiteboards, pupils' performance improves more in national literacy, mathematics and science tests compared to pupils in other schools (Higgins, 2005).
- Use of interactive whiteboards improves the performance of low-achieving pupils in English and the overall impact was greatest on writing (Higgins, 2005).
- There is an association between the length of time that students have been using computers and their performance in PISA mathematics (OECD, 2004).

Other reviewed studies provide ***qualitative*** **evidence** that ICT can impact on **learning outcomes** based on opinions of teachers, students and parents.

- Pupils, teachers and parents consider that ICT has a positive impact on pupils' learning (Ramboll Management, 2006, EUN, 2004, ITU, 2004).
- Teachers are becoming more and more convinced that the educational achievements of pupils improve through the use of ICT (Kessel, 2005).
- Pupils' subject-related performance and basic skills (calculation, reading and writing) improve (Ramboll Management, 2006).
- Academically strong students benefit more from ICT use, but ICT serves also weak students (Ramboll Management, 2006).

All the studies show that ICT has **'secondary' impacts on the learners**:

- A very high 86% of teachers in Europe state that pupils are more motivated and attentive when computers and the Internet are used in class. However, in some countries there is a substantial number of teachers, who deny that there is much of a pedagogical advantage of computer use in class (Empirica, 2006).
- ICT has a strong motivational effect and positive effects on behaviour, communication and process skills. (Comber, 2002, EUN, 2004).
- Multimedia and interactive content on interactive whiteboards is engaging and motivating, particularly for primary pupils, and students pay more attention during lessons (Higgins, 2005).
- ICT allows for greater differentiation (especially in primary schools), with programmes tailored to individual pupils' needs (Ramboll Management, 2006).
- Pupils state that they do assignments more their own way when using a computer and their parents consider that they solve assignments more at their own level (Ramboll Management, 2006).
- Teachers consider that pupils work more in cohesion with their own learning styles, resulting in a favourable impact on both academically strong and weak students (Ramboll Management, 2006).
- Pupils with special needs or behavioural difficulties gain in different ways from the use of ICT (Ramboll Management, 2006, ITU, 2004).
- Students assume greater responsibility for their own learning when they use ICT, working more independently and effectively (ITU, 2004).

- ICT offers assignments better suited for their individual needs and makes it easier to organize their own learning, through the use of, for example, digital portfolios (ITU, 2004)
- Teamwork between students is greater when they use ICT for project work (Ramboll Management, 2006, Kessel, 2005)
- ICT use at schools is a factor that helps to minimise the social divide by smoothing out the digital divide (Ramboll Management, 2006).

7. Impact on teachers and teaching methodologies

ICT has been introduced into schools during the last decade and it has now become compulsory in many countries to use ICT in teaching (both as a separate subject as well as a cross-curriculum element). Apart from the infrastructure, a necessary pre-condition for ICT benefits, the quality and quantity of ICT use in the teaching process is crucial in impacting on learning outcomes. Effective teacher practice can enhance impact, but what has been the concrete impact of ICT on teaching practices? Have teachers used ICT to improve their teaching? This chapter summarises the considerable evidence concerning the working and teaching practices of teachers and examines the more direct effects of ICT on teachers' motivation, skills and confidence which in turn impact on the teaching processes[38].

7.1. Impact on teachers

Increased enthusiasm for the use of ICT

Most of the studies show that teachers gain a positive attitude towards ICT through government interventions and training programmes. The evaluation of the Norwegian Pilot project 1999 to 2003 (ITU, 2004) found that teachers have a more positive attitude towards ICT. In Denmark ICT is now higher on the agenda in primary and lower secondary schools and the large majority of teachers have more frequent discussions than three years ago. (Ramboll Management, 2005).

Issuing teachers with their **own laptop** computer has increased positive attitudes and teachers' confidence in using 'hands-on' experience with ICT for education. (Becta, 2003).

Teachers in the UK taking part in the **interactive whiteboard (IWB)** pilot project were extremely positive about the technology. They were convinced that the changes were improving teaching and learning in lessons. However, despite the enthusiasm, it remains unclear if this translates into effective and purposeful added value practice. The authors (Higgins; 2005) state that for the use of interactive whiteboards to be justified it must be used in ways which provide more effective learning above and beyond that which is possible with other kinds of projection technology or just normal whiteboards.

The ERNIST ICT school portraits (European Schoolnet, 2004) clearly underpin the positive effect of IWB's on teachers and the learning situation, even if they are used to support existing practice. *"The new interactive whiteboards in some ways replace existing practice. However we feel it is more accurate to say that they have helped teachers become even more innovative in the resources they can bring in front of the pupils, and pupils learn more effectively given the plethora of stimuli that is now before them. In no way have the boards stifled teaching. The software is so flexible that most, if not all, teachers can use them. If anything, they have indeed helped organise the work of the teacher."* ICT Co-ordinator from School portrait Aquinas Grammar School, Northern Ireland.

[38] Findings in this area are based on perceptions of teachers, lesson observations or case studies. Context dependency makes it difficult to generalise findings in this area. (As it is true for quantitative data, too), but it allows us to see what works for whom under which conditions.

Strand 3 of the Impact 2 study, focussing on learning and teaching environments, raises concerns about the actual impact of ICT despite the positive perception of teachers: "whilst networked technologies are valued by teachers as an educational tool, strategies for their effective use are still developing. Teachers and pupils are clear about the potential of ICT, but not always able to articulate what is being learnt as a result of its use." The question is whether this is because of the lack of knowledge to integrate ICT into a concrete pedagogical goal, the technology itself or teacher's lack of reflecting on their profession.

Increased efficiency

Looking at the studies there is evidence of immediate increases in ICT use in the day-to-day work of teachers such as increased efficiency in planning and preparation of work due to a more collaborative approach between teachers.

However, teachers' opinions are divided over time gains using ICT. On the one hand teachers complain about the lack of time to integrate ICT; on the other hand studies show that there are considerable time savings in medium and long term planning which can be corporately shared in reducing teachers' workload as the ICT test bed study shows (Underwood, 2006). There seems to be a need to show teachers how ICT can save time, if efficiently used. "We need to shift the focus on process management to put into place new ways of working to maximise the value of ICT" (Underwood, 2006).

The Eurobarometer Benchmarking report suggests that some countries focus more than others on ICT support or maintenance contracts in schools to support teachers to make use of ICT in teaching and not losing time in fixing configurations or software and hardware problems. Availability ranges from 12% in Portugal to 82% in the UK with a European average of 47%.

The elearning Nordic study (2006) results suggest that more frequent ICT users perceive a greater positive impact of ICT in general and do not see it as a waste of time once they get over a certain threshold. It found that the cluster including teachers not reporting an impact of ICT contains the most teachers who find that ICT in their school has resulted in more teaching time being wasted. The cluster of experienced ICT users does not mention this aspect.

As ICT offers new and better opportunities for differentiated learning, students work more independently and so teachers have more free time to assist individual students according to need – identified in the Norwegian Pilot study (ITU, 2004).

Increased co-operation and planning with ICT

An overwhelming majority of teachers in Europe (90%) already use ICT to prepare their lesson (Empirica, 2006).

81% of teachers taking part in the interactive whiteboard project believe that their workload has increased, but 35% of these consider the increase only temporary. The study provides strong evidence that **ICT has enabled teachers to cooperate more and share curriculum plans with colleagues and managers**, which saves time in the preparation of lessons. Impact 2 (Becta, 2002) also confirms that teachers can use ICT to plan lessons more efficiently and more effectively.

Broadband is a major factor in increasing collaboration between teachers (Underwood 2005). [39]Teachers benefit from broadband in several ways:

- New ways of communicating between staff, staff and pupils, sharing of expertise and knowledge within and between schools, and communicating between the home and the community (currently limited, but a growing feature of the schools surveyed)[40]
- Better and faster access to a rich source of learning resources allows teachers to gain confidence and learn about the possibilities they offer.
- Access to lesson ideas and materials aids teachers in their planning, which reduces time spent on initial preparation whilst increasing time available for developing and sharing ideas with colleagues.
- The ability to tailor learning packages to individual pupils by provision of various learning tasks

Despite the various possibilities broadband offers, the study shows that it seems to be primarily exploited as a tool to improve administration: "Schools with the highest levels of connectivity made more use of their broadband connections for administrative purposes." While both primary and secondary teachers use this technology in equal measure to support teaching and preparation and, to a lesser extent, for professional development, secondary teachers were more active users of the technology for administration. The broadband study highlights specifically how teachers extend the range of activities and modes of working once they have a reliable technology. The study potentially describes potential profound changes in pedagogical practices but they have not materialised yet on a larger scale, which is a general problematic issue with ICT integration.

Student data management

There is evidence of radical beneficial changes in planning and sharing materials and recording assessments and examples of ICT-led assessments where electronic collection of samples of pupils' work is used to validate and moderate baseline assessment. The UK Test Bed evaluation (Underwood, 2006) provides significant evidence of profound changes in working practices of teachers. The underlying reasons may lie in the conditions of the project itself: high levels investment in ICT, including the incorporation of Management Information Systems, which have fostered collaborative approaches. There is significant evidence of ICT being used to formalise co-operative planning via the sharing of curriculum plans and the analysis of students' data. Teachers keep records of pupils' work electronically which can be stored and analysed collaboratively. This in turn has led to clearer target settings and to improvements in reporting to parents.

Limited use of LMS or VLEs

Studies looking at the use of Learning Management Systems (LMS) or Virtual learning environments (VLEs) do not give a positive picture in terms of their pedagogical use or as a knowledge sharing tool. Elearning Nordic, for example, shows that schools have invested in Learning Management Systems to improve knowledge sharing, but the systems are primarily being used by teachers to communicate with other teachers and not to communicate with pupils and parents. In The Netherlands, VLEs are gradually being incorporated into education but use is still limited. In the UK, virtual learning environments are now being

[39] However, only two –third of EU schools have broadband access. (Empirica, 2006).
[40] Impact 2 shows that the use of email to bridge home-and school environments is still under-exploited. Elearning Nordic also found that ICT is predominantly used by the teaching staff for communication among themselves and to a lesser degree for communication with pupils and parents.

installed, but more training is needed to support innovative pedagogy, as the ICT Test Bed study shows.

7.2. Pedagogical Practice

Despite increased enthusiasm by teachers, and increasingly realised time gains through experienced use of ICT and more knowledge sharing between teachers, pedagogical gains that directly influence students' learning are yet to be shown.

The studies under review try to identify impact of ICT on pedagogy by observing and analysing:

- The use of specific technologies and applications by teachers
- Teacher-student relationships
- The overall use of ICT
- Teachers' competencies and confidence

Specific technologies and applications

Observing Internet use, the Impact 2 (Becta, 2006) found that **structured approaches to Internet** research had the potential to develop students' search and research skills which were transferable across the curriculum. These approaches involved various processes such as the use of keywords, the identification of likely information sources, the evaluation of resources found, and the adaptation and synthesis of information from various sources.

Using email to create more authentic situations in collaborative projects was a favourite approach for some teachers in the Impact 2 case studies observed. Collaborative projects developed most effectively where a clear curriculum context had been established on both sides. The elearning Nordic study also identifies chats as a means of authentic language teaching. However, it is important that teachers invest time beforehand to set the conditions for a "safe chat".[41]

The interactive whiteboard study (Higgins, 2005) found that **interactive whiteboards make a difference to aspects of classroom interaction**. There is a faster pace (number of interactions between teachers and students) in the whiteboard lessons compared to the non whiteboard lessons. However, this raises the question of how much time remains for students to reflect on the content and engage in a learning process. With regard to teaching styles researchers found an embedding effect of IWB a year later whereby teachers continued to ask more open questions, repeat questions and probe questions (by asking for further information or an explanation of the answer from a pupil). Teachers also give more evaluative responses in whiteboard lessons and address follow up questions to the whole class rather than to an individual pupil. The study found that pupils' responses were used to involve other pupils in the lesson. In another study (Miller et al 2004), teachers use interactive whiteboards to support their didactic approach, an interactive approach or an enhanced interactive approach. The enhanced interactive approach integrates conceptual and cognitive development in a way that exploits the interactive capabilities of the technology.

The ERNIST ICT schoolportraits found that involvement of students was increased in good instructional lessons, by means of interactive whiteboards, but also a lot of constructivist approaches where ICT played a pivotal role where observed.

[41] For more information on Internet safety see http://www.saferinternet.org

They found many examples of teachers that innovate their traditional classroom lessons by making them more interactive, more visual and more stimulating.

Teacher-student relationships

New roles of teachers are identified in the Norwegian pilot study with the **teacher being more of an advisor, critical dialogue partner and leader for specific subject domains**.

The Impact 2 study (strand 3) looked at a recurrent claim for the impact of ICT in educational contexts: its potential to alter the teacher-learner relationship, in particular to shift the balance from the dominant provider/recipient model to a more facilitative approach, thereby promoting greater independence of learning. Despite clear evidence that learners work more autonomously with ICT, Impact 2 suggests that this is not necessarily associated with a fundamental shift in teaching practices or roles. It has partly to do with teachers' lack of confidence in using ICT in their subject area, or occurred 'by default' because of the independent nature of working with the computer.

However, teachers were also aware that ICT could change they way they interact with their pupils. This was evident when teachers encouraged students to explore software within a **clear structure of teacher support and intervention**. Increased pupil autonomy also brings with it less teacher control over activities and therefore teachers report monitoring problems:" It was not always possible to determine the extent to which the pupils were actually learning." Control is a concept deeply rooted in traditional teaching and education and so giving up control and placing more trust in pupils seems to be difficult for teachers (see also the Tiger in Focus study).

The Impact 2 case studies reveal that even though most teachers recognise the potential benefits of collaborative working with ICT, far fewer actually capitalise on this. The Impact 2 study concludes that some of the **best examples of the use of ICT** were when lessons moved through different modes of teacher/pupil interaction, which involved both in a **variety of roles**, and where **intended and actual use** coincided.

General use of ICT

The Eurobarometer Benchmarking survey states important areas of current ICT use by teachers across Europe. Teachers teaching science, mathematics and computer science (22%) and active in vocational education 23% are the most intensive users of the computer in class (in more than 50% of the lessons). This compares to only 5% of the literature and language teachers and with those in primary education (17%), humanities and social science (13%) and physical and artist/crafts education (16%) in the mid field.

Many teachers in the Impact 2 study refer to ICT as a tool. This suggests, as the author state, that ICT is an add on element to existing practice, e.g. using a word processor for copying out a hand written text or using the Internet when a textbook or CD-Rom might have been a perfectly adequate source of information.

However, this is arguable as for example the use of the Internet as a tool distinguishes itself from a textbook and is as such not comparable. Values of both tools depend on the teachers' ability to use them in a pedagogical meaningful way.

The researcher also found more transformative use of ICT where ICT was used within a curriculum context, more "built in" than "bolt on".

Here again, a simple distinction between "built in" or "bolt on" does not tell the whole story: There are three aspects that need to be separated according to the experience of the Dutch Inspectorate gained within the ERNIST ICT school portraits: [42]
1. The affordances of technology: Does it possess characteristics that enable transformation?
2. The relationship of the technology use with the curriculum.
3. The pedagogy that teachers use. There have been many examples where the use of the technology was innovative, interesting and transformative, but completely 'bolt on'. In other cases the use of simple technology was really 'built in' but in a traditional pedagogy.

The ICT Test Bed evaluation (Underwood 2006) provides further evidence that **teachers use ICT to support existing pedagogies**: "New technologies that provide a good fit with existing practices, such as interactive whiteboards are first to be embedded, but others like video conferencing, digital video and virtual learning environments are now being incorporated, providing evidence of ongoing learning by the workforce. Training needs to continue to support innovative pedagogy."

Both examples show that ICT is being gradually integrated in an ongoing process and taken forward from traditional practices.

ICT can therefore enhance teaching in several ways:

1. by enhancing what is already practiced and
2. by introducing new and better ways of teaching and learning.

Transformed teaching is more difficult to achieve. "Changes that take full advantage of ICT will only happen slowly over time, and only if teachers continue to experiment with new approaches." (Underwood 2006)

The evaluation of the teacher training seminar in IT during the ITMF project showed that teachers have not really changed their use of ICT in education, but their way of thinking about the application of ICT in education. Teachers have increased their use of ICT in lessons where students search for information on the Internet and have furthered the use of both standard and subject specific applications, but there was hardly any effect on students' use of ICT for presentations or communications. **Teachers do not yet exploit the creative potential of ICT and engage students more actively in the production of knowledge.**

Likewise the elearning Nordic study shows an increase in the use of ICT for teaching but not the introduction of revolutionary teaching methods: "ICT generally has a positive impact on teaching and learning situations, but compared with the ideal expectations, the impact of ICT on teaching and learning must still be considered to be limited" (Ramboll, 2006). Many teachers use ICT to support traditional learning methods, for example, information retrieval in which students are 'passive consumers and receivers' of knowledge instead of 'active producers' of new knowledge). This seems to be striking in a culture where traditionally constructivist approaches hold sway. Half the teachers in the Nordic schools never involve their pupils in developing a media product and 20 percent do this only

[42] Bert Jaap van Oel, Inspector, Dutch Inspectorate of Education.

rarely. Internet research also seems to be a more passive exercise for students – with teachers learning most!

The study identified several distinct and actual areas of teaching with ICT:

- Engaging students in project oriented tasks and encouraging them to work in groups as well as individually, e.g. searching for information on the Internet;
- Differentiating between students;
- Enabling pupils more often to work individually than together (with huge differences between the Nordic countries);
- Using ICT where and when it supports the subject content of their teaching, rather than to support their pedagogical methods.

The latter argument leads us to conclude that traditional models of teaching still prevail. Teachers have a strong focus on subject-related content within a given curriculum. They focus on results, not on the processes of learning or teaching itself. If the curriculum remains mainly organised around core subjects, teaching will not change profoundly and a traditional way of delivering content will stay in the foreground. In this respect the results of the elearning Nordic country are quite surprising as there the curriculum is mainly goal-oriented and allows for different teaching methods to a achieve the set goals.

School leaders estimate that the impact of ICT on teaching methods in their school is low. Even though 90 percent of heads view ICT as a tool to support pedagogical development and school development, only 42 percent consider that ICT to a large degree has contributed to the inclusion of new pedagogical methods in their school. A cluster analysis defined the characteristics of those teachers who consider 'a great positive impact and 'the greatest impact of ICT' (as opposed to no or moderate impact). Teachers, who report a great positive impact think that ICT improves pupil performance, consider ICT as a tool to support both subject content and pedagogy and think ICT has an impact on teaching. They are the most ICT confident, use ICT the most, use ICT in the most project–oriented, collaborative and most experimental ways.

The Nordic study found that **the impact of ICT is highly dependent on how it is used**. Teachers see the greatest impact of ICT in quite different teaching and learning situations. Some teachers feel ICT has greatest impact when used to as a tool to create a physical product, others see ICT as a powerful tool to support group and project work. School culture and the personal views of teachers working with ICT determine to a large extent specific ICT uses.

Previous studies (EUN, 2002) have shown that there are also major differences between primary and secondary schools regarding the integration of ICT by teachers. As elearning Nordic also shows, primary teachers more often regard ICT as supporting their pedagogical and didactical teaching methods than teachers in secondary school. It would be interesting to describe the teaching methods used in primary schools and the way ICT is supporting these and relate them to the contextual factors for ICT use in a primary school context (timetables, size of class, curriculum). On the other hand, the European Benchmarking report shows that despite good general conditions in primary schools, the potential is not exploited with only 17% of primary education teachers using computers in their classes.

The Tiger in Focus study (Toots, A. et al., 2004) analysed the impact of ICT developments on the teaching process and pedagogy in Estonian schools.[43] It identified two types of teacher: the "classical type" and the "constructivist type". They differ most significantly in performance assessment and spatial organisation of learning. Constructivists allow pupils to visit the library and the computer class to do their study tasks, arrange work stations and keep all learning tools including PCs freely accessible for students. They also encourage student involvement in the assessment process. The study concludes that there is a potential for pedagogic innovation in schools but the process is still beginning with the majority of teachers stressing the importance of information searching, word processing and analysis. Constructivists are willing to implement a more individual approach to learning based on student's interest and pace of learning. Only a few are prepared to involve students in the planning of the learning process, select topics or set deadlines for tests.

Teachers' competencies and confidence

So what are the reasons for still not exploiting the potential of ICT for new pedagogical approaches? Have training programmes failed to achieve a shift in teaching practices with ICT?

National competence development programmes have had limited impact on teachers' pedagogical competences applied in day-to day school practice. They increased the knowledge about the use of ICT in pedagogy, but teachers could not translate this knowledge into efficient everyday practices. Where ICT has been embedded over a longer period this has led to more use of ICT by teachers and increased considerably their confidence using ICT. Moreover, an experimental approach using ICT in everyday practice is an important factor in increasing teachers' pedagogical competence.

The ITMF evaluation (Ramboll Management, 2005) illustrates the current dilemma concerning the pedagogical use of ICT. Even though a large number of teachers have gained more pedagogical knowledge (through better access to ICT-based learning material and pedagogical concepts via training and discussions), teachers have increased the use of ICT but only a few have had the goal to integrate ICT in the curriculum. In some cases the reasons for selecting a technology are affected more by teachers' user skills than by professional considerations.

The ITMF study found that "**the greatest impact is found in relation to teachers who are experienced users and who from the start had already come far with the integration of ICT in their teaching**." This result is supported by the elearning Nordic study which found that teachers who report a moderate impact of ICT (42%) have participated in ICT competence development within the last three years, mostly on the pedagogical use of ICT in teaching. However they do not feel to have sufficient competence to integrate ICT into their teaching. More positive results have been found in Norway at the end of the PILOT study: 63% of teachers believed that ICT has been a valuable support in solving pedagogical problems and 65% in solving organisational problems.

Similar positive results come from the Interactive Whiteboards (Higgins, 2005) and test bed project in the UK (Underwood, 2006). The overwhelming majority (98%) of teachers participating in the interactive whiteboard project in the UK said that they were more confident in using ICT in general after using the IWB. Test bed project teachers reported exceptional gains in competence and

[43] The other two focus areas were: Main patterns of ICT use in school and out of school and ICT and Change in the school culture.

confidence, now using ICT routinely in their teaching. Secondary teachers' use is more varied between departments and individuals but many are making extensive use.

The study on broadband found that the reliability and capacity of broadband supported classrooms led to increased confidence in the technology for all users. Broadband allows technology to become embedded throughout a school and thus changes the ways teachers organise lessons and cooperate with colleagues. This goes beyond the impact of broadband on particular broadband dependent activities such as video conferencing.

The ICT Education monitor 'Eight years education & ICT" (2005) found that training in didactic ICT skills in courses and in-service training attracts relatively little attention as a means of ensuring increased use of ICT in education. Schools prefer to let teachers experiment and acquire knowledge and experiences in stages. The study mentioned that **teachers' basic ICT skills have increased dramatically** (word-processing, email, Internet) but that a quarter of teachers are still not conversant with applications like spreadsheets and databases. As regards pedagogical ICT skills, less than half of teachers (40%) consider themselves competent enough to use ICT in a didactically acceptable manner. The study also shows that only 40 per cent of teachers use email in education. There is a striking increase in the use of presentation programmes by teachers and pupils alike. **The use of ICT for communication with and between pupils is still in its infancy.**

The overwhelming body of evidence shows that the majority of **teachers have not yet embraced new pedagogical practices. The foundations for more profound changes have been laid, but more time is needed to achieve wider impact on teaching methodologies**. There is a long continuum and slow pace in which teachers adopt new technologies. Apart from enthusiasts, who adopt ICT at a much faster pace, the majority of teachers explore ICT as a tool. First ICT is used to enhance existing traditional practice. Second, it is progressively built into the curriculum. Only in a third stage ICT is used to transform more profoundly their teaching practice. This transformation of teaching and learning processes is a long term process. The outcomes will be therefore visible only in years to come.

Moreover, most of the characteristics of ICT-based teaching are context dependent, such as curriculum context or the organisational set up in schools and therefore do not lie not in the immediate control of teachers. They are rather determined by the school management and education policy frameworks.

Specific government interventions, such as the IWB project and the test bed project in the UK, seem to have had a more positive impact on teachers in terms of enhanced teaching practices than large scale national teacher training programmes. Positive factors of these kinds of interventions are:

- They are implemented directly in and with the school and more directly followed up over a longer period;
- Teachers are guided, supported on the workplace and part of a project, which means more control and ownership.

Moreover, the ERNIST ICT school portraits show that in-house professional development, where early adopters spread good practice, both through regular meetings and through specialised ICT development programmes has clear advantages. This helps to see what is on offer close to the school curriculum, to the teacher needs and classroom practice. Peer learning is usually very effective and more sustainable in the long run, something that can not be built in distance training programmes.

Pedagogical approaches are decisive for ICT integration and the extent of impact it may have. Teachers' pedagogies and pedagogical reasoning influence their uses of ICT and thereby pupil's attainment (Becta, 2003). The following table illustrates characteristics of ICT-based and traditional teaching. Grey areas indicate where evidence was found in the studies.

Area	**ICT based teaching**	**Traditional teaching**
Approach	Constructive (and instructive)	instructive
Teaching	project based teaching	pre-programmed teaching
Teaching plan	based on a theme	subject focus based on a firm outline and standards
Task	must be fulfilled individual or collective	having particular knowledge everybody does the same
Learning	understand the context	memorising facts
Subjects	linked to topics	separate subjects
Pupils	divided by skills and interest differentiation	divided by age
Evaluation	mistakes are source for improvement and guidance oral feedback formative assessment	correction only marks and grading as part of the evaluation of students
Teacher	guider and mediator has several roles	high authority has one role
School	open environment	closed environment
Source of information	multiple	teacher

7.3. Research methods to assess the impact of ICT on teaching

All the studies analysed provide a rich evidence base of how ICT is used by teachers. However, they look at different aspects and use different methods to reveal an impact of ICT on teaching methodologies.

The main focus of the elearning Nordic study was to capture the impact of ICT based on teachers, pupils, parents and head teachers' opinions. This, as the study points out, has its limitations with regards to the actual impact by teachers which can be in sharp contrast to what is perceived. Another limitation of this approach is that it therefore does not give reliable evidence on the quality of ICT use of teachers (though it measures use of ICT by teachers) nor does it reveal specific pedagogical approaches with ICT and the circumstances that accompany a given practice. However, being a large scale study with more than 8000 people involved in four different countries it tells the current "state of mind" of teachers in important aspects of teaching with ICT which goes beyond a national level. The quantitative findings based on questionnaires with teachers are illustrated with selected examples from schools. The cluster analyses of teachers experiencing different levels of impact reveals some interesting characteristics that can be generalised.

The Impact 2 study (Strand 3) carried out a number of case study evaluations and gathered qualitative data including interviews, video diaries and classroom observations to further explore the perception and concepts of teachers. This approach has provided more in- depth data on the approaches to teaching considering related factors that appear in a given teaching-learning situation and that need to be included to interpret the result and which go beyond pure observation or quantitative questionnaires to teachers. They can differentiate, for example, between intended and incidental use of ICT by teachers.

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[44] in order to have a clearer qualitative picture of how ICT impacts on teaching.

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

[44] 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)

detecting innovative pedagogical practice, patterns of use and educational trends is a promising approach.

To summarise

There is considerable evidence of the impact of ICT on teachers and teaching, not all of it positive.

Benefits for teachers

- Teachers gain a positive attitude towards ICT through government interventions and training programmes, which have led to a 'routine' use of embedded ICT (ITU, 2004, Ramboll Management, 2005, Higgins, 2005).
- An overwhelming majority of teachers in Europe (90%) use ICT to prepare their lessons (Empirica, 2006).
- Teachers use ICT to plan lessons more efficiently and more effectively due to a more collaborative approach and the sharing of curriculum plans with colleagues and managers. (Higgins, 2005, Harrison, 2002).
- Effective exploitation of Information Management Systems leads to increased and formalised cooperative planning between teachers, and this has a positive impact on teaching practices (Underwood, 2006). However there is not a positive picture of the use of Learning Management Systems or Virtual Learning Environments. They are still underexploited and used predominantly for administrative purposes. (Kessel, 2005, Underwood, 2005, Ramboll Management, 2006).
- Primary teachers consider ICT to have more impact than secondary teachers (Ramboll Management, 2006).
- Embedded ICT over a longer period of time has lead to more use of ICT by teachers and considerably increased their confidence in using ICT (Ramboll Management, 2006, Underwood, 2005).

Pedagogical practice

Specific ICT uses

- Issuing teachers with their own laptop computer increases positive attitudes towards their work. (Becta, 2003).
- Structured approaches to Internet research develop students' search and research skills which are transferable across the curriculum (Becta, 2006).
- Broadband is a major factor in increasing collaboration between teachers. Embedded, reliable and high-capacity broadband in the classroom increases the quality and quantity of educational activities that can be undertaken (Underwood, 2005).
- Interactive whiteboards make a difference to aspects of classroom interaction (Higgins, 2005).

Teachers' competencies and general use of ICT

- National competence development programmes have had limited impact on teachers' pedagogical competences. School leaders estimate that the impact of ICT on teaching methods in their school is low (Ramboll Management, 2006).
- Teachers' basic ICT skills have increased dramatically (Kessel, 2005).
- Teachers teaching science, mathematics and computer science (22%) and active in vocational education 23% are the most intensive users of the computer (Empirica, 2006).
- Teachers use ICT to support existing pedagogies. ICT is used most when it fits best with traditional practices (Underwood, 2006).
- ICT can enhance teaching by enhancing what is already practiced or introducing news and better ways of learning and teaching (EUN, 2004)
- The greatest impact is found in relation to teachers who are experienced users and who from the start had already come far with the integration of ICT in

their teaching. Teachers who perceive a highly positive impact of ICT use ICT in the most project-oriented, collaborative and experimental way (Ramboll Management, 2006)

- With ICT, the teacher tends to become more of an advisor, critical dialogue partner and leader for specific subject domains (ITU, 2004).
- The impact of ICT is highly dependent on how it is used. The impact of a specific ICT application or device depends on the capacity of the teacher to exploit it efficiently for pedagogical purposes. Factors beyond the teacher's control influence ICT uptake, e.g. institutional cultures, leadership, the curriculum and assessment (Ramboll Management, 2006, Ramboll Management, 2005).
- Teachers do not yet exploit the creative potential of ICT and engage students more actively in the production of knowledge. Teachers' use of ICT for communication with and between pupils is still in its infancy. ICT is underexploited to create learning environments where students are more actively engaged in the creation of knowledge rather than just being passive consumers (Kessel, 2005, Ramboll Management, 2006, Ramboll Management, 2005).

8. Barriers for effective ICT use in schools

Although teachers appear to recognise the value of ICT in education, difficulties nevertheless continue to be experienced within the processes of adopting these technologies and as has been shown in the studies only a minority has so far embedded ICT into teaching. In order to ensure realistic and holistic solutions for policy makers the factors that prevent teachers from making full use of ICT must be identified and understood. The following analysis aims to present the perceived barriers to the use of ICT which were highlighted in the reviewed studies and examine their causes and effects. The barriers are broadly divided into three categories: teacher-level barriers, i.e. those related to teachers' attitudes and approach to ICT, school-level barriers, i.e. those related to the institutional context and system-level barriers, i.e. those related to the wider educational framework.

Teacher level barriers

- **Lack of ICT skills**

The evaluation of the ITMF project in Denmark and the E-learning Nordic study revealed that in some cases the reasons for selecting a technology are affected more by the teacher's skills than by professional consideration: '*Many teachers still chose not to use ICT and media in teaching situations because of their* ***lack of ICT skills*** *rather than for pedagogical/didactics reason'*. In the Netherlands, on the other hand, teachers' ICT knowledge and skills is not regarded anymore as the main barrier to ICT use. But even though they are regarded as less of a problem, and despite teachers' ICT training, there is still a lack of follow-up on the utilization of newly acquired skills.

- **Lack of motivation and confidence in using ICT**

Their limited ICT knowledge, makes teachers **anxious about using ICT** in the classroom and thus do **not feel confident** to embrace new pedagogical practices. The 2004 Becta survey on the perceived barriers to the uptake of ICT by teachers[45] also refers to the *'teachers' fear of admitting to their pupils their limited ICT knowledge'*. In addition Elearning Nordic shows that teachers who do not experience any impact of ICT asses that they only to some or a lesser degree have sufficient ICT competences to integrate ICT into their teaching.

The Eurobarometer Benchmarking survey (Empirica 2006) analysed teachers' data according to the Access, Competence and Motivation Model (CTS) developed by Viherä and Nurmela (2001). It found that more than 80% of the European teachers describe themselves as competent in using computers and the internet in classroom situations, two-thirds have the necessary motivation for doing so (in their own opinion), and 60% describe the ICT infrastructure in their schools and the internet connection as sufficiently rapid. However, there are large variations across the countries on all three dimensions. In some countries, for example, more than half of the teachers do not feel competent yet to use the ICT infrastructure in the classroom, with Greece (60%), Portugal (70%), Hungary (71%) and France (76%) ranking at the bottom end. It appears as if motivation seems to be a critical factor, since 14% with access lack both motivation and competence and another 10% also lack motivation despite their competence and access to ICT.

[45] Becta (2004) 'A review of the research literature on the barriers to the uptake of ICT by teachers'.

Recurring technical faults, and the expectation of faults occurring during teaching sessions, are likely to further reduce teacher confidence and cause teachers to avoid using the technology in their lessons. The evaluation of the IWBs project confirms that there is some frustration every time there are technical problems. It could be stated that the more frequently breakdowns of equipment occur (perhaps due to poor quality or lack of preventative technical maintenance); the more likely teachers are to avoid using ICT in the first place.

- **Inappropriate teacher training**

Unsuitable teacher training programmes fail to engage teachers in using ICT both during their lessons and also in the preparation of lessons beforehand. The most commonly mentioned cause of this is that training courses **focus** mainly on the development of ICT skills and **not on the pedagogical aspects of ICT**. It is interesting to observe that although some teachers have good ICT skills in terms of their own personal use, they are unable to transfer these skills to using ICT in the classroom (Becta, 2004). Traditional teacher training does not prepare teachers for facilitation and support roles that are required in student-centred learning.

Furthermore, training courses are usually **not differentiated** to meet the specific learning needs of teachers and they are rather **'up-front' than regularly up-dated** and followed-up sessions. The need for continuation in the field of teacher training is also emphasised in many studies (ICT test bed study, Elearning Nordic) since 'increased competence leads to a demand for even greater competence and to support for innovative pedagogy'. Up-to-date training in specific ICT skills is essential particularly for teachers of a more advanced age that did not receive any ICT education during their studies.

Developing the skills to engage effectively with the technology and creating structures to enhance ICT use is as important as investing in ICT infrastructure. Therefore effective training is crucial if teachers are to implement ICT in an effective way in their teaching. On the contrary, when training is inadequate or inappropriate, teachers are not sufficiently prepared, and perhaps not sufficiently confident, to make full use of technology in the classroom.

School – level barriers

Even after receiving basic and pedagogical training in ICT, some teachers are still not able to make use of that training since they are hampered by a range of school level factors. These are:

- **The absence and poor quality of ICT infrastructure**

The availability of technology is not necessarily a factor for the successful implementation of ICT, yet the **absence of technology** is a crucial hindrance, as analysed in E-learning Nordic, for example. The provision of ICT infrastructure does not necessarily mean that use will be higher. On the other hand, some studies (e.g. E-learning Nordic) show that in schools with more ICT equipment, headmasters consider that ICT has encouraged the integration of new pedagogical methods into teaching.

The **lack of high quality hardware** and **suitable educational software** is also considered by the majority of ICT coordinators as an important hindrance to further development of ICT in education. Poorly maintained computers are usually unreliable and likely to cause disruption to even the best planned lessons. Similarly, inappropriate software does not enhance a lesson in any way and rather disengages both teachers and students from the learning process.

Therefore, the amount, range and quality of ICT resources available to the teachers are an important influence on the use made of ICT in subjects and classes. Of course, the high cost of ICT maintenance, and software licenses should be also taken into consideration since it further inhibits ICT usage in schools. In addition there is the need to customise and standardise software.[46]

- **Limited Access to ICT equipment**

The inability of teachers and students to access ICT resources is a result of a number of other factors and not only of the lack of ICT infrastructure. Sometimes a school may have high quality of ICT resources but these are inappropriately organized and thus not optimally used. In some schools for instance, prior booking of the ICT classroom is required, or the internal school network cannot be accessed from outside. As a result teachers and students do not have the opportunity to use ICT at any time according to their needs.

- **Schools' limited project-related experience**

Many schools have limited experience with systematic planning and implementation of development projects and follow-up. Ramboll Management estimates that the main barrier for the ITMF projects has been that the framework for the implemented development projects has not been the best: if schools had participated in more projects, they could have been able to better respond to the requirements of national initiatives (such as ITMF).

- **Lack of experience in project-based learning**

The Elearning Nordic study shows that most of the teachers who report the greatest positive impact of ICT were experienced in project-oriented teaching supported by ICT, while half the teachers who report no impact of ICT seldom or never did this. It is also the teachers who experience the greatest impact of ICT who are most often engage their pupils in learning activities in which pupils are asked to work exploratively and innovatively supported by ICT. Yet, these activities are carried out by enthusiasts and lack continuous involvement of the *whole* school or the *whole* municipality with a view to anchorage and dissemination of the results.

- **Absence of ICT mainstreaming into schools' strategies**

Schools face the problem of unsuccessful organisational implementation of ICT because ICT is not seen as a part of the general strategy at school level. Even if some schools have developed ICT strategies, these are not integrated into the school's overall strategies. Yet ICT is no longer a goal itself, an isolated phenomenon requiring a special strategy. Instead, it should be used to support whole school development.

System-level barriers

- **The rigid structure of the traditional schooling system**

Sometimes education systems work against ICT impact and even if educators are not ICT-resistant, in some cases the system under which they work is.[47] For example, in UK, national tests are not made for ICT rich schools. Studies such as the Test Bed study give some valuable results concerning the factors that impede

[46] EUN has carried out the following survey on the availability of curriculum related digital learning resouces: Can European teachers find curriculum related digital learning resources? The LIFE survey on curriculum related search possibilities in national and regional school portals in Europe European Schoolnet, December 2006. http://wiki.eun.org/life-wiki/index.php/Main_Page

[47] On the other hand it could be argued that teachers might not be always aware about the possibilities they have and make full use of its capacities.

the effective use of investments in ICT. As it was shown in the study investments in ICT are not able to have an impact they should have in secondary schools within the present education system. The study 'Innovative learning Environments' (2004) has shown that teachers and parents are still nervous about the new methods' capacity to lead to the same results in national exams and fear that schools using ICT will be less performing than traditional schools. For example, in the Impact2 study some teachers explain that very little use of ICT was made in Key Stage 3 English, because of the need to prepare for the public examinations.

Indeed, existing assessment and evaluation methods primarily focus on content and neglect social and other abilities of learners. Competencies such as problem solving, presenting material in novel ways, collaboration or creativeness are only to a limited degree covered in national exams. Students receive no credit for these new competencies they have developed, even though they are important for the development of the society.

Yet, this is evident in some countries more than in others; in Finland for instance, where differences between schools are fewer and assessment is based more on evaluation, this is less the case.

To summarise

The main factors that prevent teachers from making full use of ICT can be broadly grouped into three categories:

- *Teacher-level factors*
  - Lack of teacher ICT skills;
  - Lack of teacher confidence;
  - Lack of pedagogical teacher training;
  - Lack of follow-up of new ICT skills;
  - Lack of differentiated training programmes

- *School-level factors*
  - Absence of ICT infrastructure;
  - Old or poorly maintained hardware;
  - Lack of suitable educational software;
  - Limited access to ICT;
  - Limited project-related experience;
  - Lack of ICT mainstreaming into school's strategy

- *System-level factors*
  - Rigid structure of traditional education systems
  - Traditional assessment
  - Restrictive curricula
  - Restricted organisational structure

9. Summary Conclusions

Evidence Based Research

Measuring changes in learning and teaching processes is a time-consuming task, but one which may yield valuable results. Knowing how educational technology changes teaching practices as well as the ways in which students learn, is fundamental for evaluating its effectiveness and for developing better tools. We also must be sensitive to the ways in which technology use can affect outcomes, and must consider the ways in which individual differences change the use of technology as well as learning processes and outcomes.

The evaluation of impact of government initiatives is crucial to inform decision makers on whether to expand or modify a particular policy or programme and develop future actions. The study shows that the evidence available from the evaluation of government initiatives and broader impact studies is unevenly spread across Europe. There is a predominance of UK research in the field.

Furthermore, 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.

The review also shows that current education systems hinder ICT impact. Correspondingly impact studies and evaluations often measure against traditional systems, where the potential of ICT can not be fully exploited.

Where studies have been conducted to measure the direct impact of ICT on student learning and teaching it has not been possible to identify a purely ICT effect disentangled from other elements of the learning environment. Furthermore, it has become increasingly difficult to measure student learning as more is understood of the complexities of learning. These factors have to be taking into consideration when looking at the evidence for ICT and learning outcomes and ICT and teaching methodologies.

ICT and learning outcomes

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.

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)[48] 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 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 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 and teaching methodologies

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

[48] See Annex 1.

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.

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.

Barriers

More concretely impact studies have identified the major barriers preventing more successful integration of ICT and achieving higher impact. They can be grouped under teacher level barriers (micro level), school level barriers (meso level) and system level barriers (macro level).

On the micro level the lack of ICT skills of teachers and the updating of these skills is still a major barrier as it affects teachers' choice of a specific ICT much more than professional consideration. This, on the other hand influences the capacity of teachers to embrace new pedagogical practices with ICT. As mentioned beforehand there are other outside barriers that prevent teachers to embrace new technologies to the full extent.

On school level, ICT infrastructure and access to ICT is still a major issue. As often shown the availability of technology alone is not the only factor for successful integration of ICT, but its absence or poor quality due to insufficient maintenance is a crucial hindrance. Schools without sufficient ICT resources are

clearly missing out on the extra educational opportunities ICT can offer. Other inherent barriers at school level are organisational set ups which are linked to leadership issues and a strategy for ICT. The latest evidence shows that ICT strategies, in order to be effective, need to be integrated into the overall vision of the school. Moreover, where headmasters have used ICT to develop the school's values, teachers perceive a more positive impact of ICT.

The evidence also proves the recurrent claim of reducing system level barriers mainly that of existing assessment and evaluation methods which do not take into account new competencies acquired by using ICT in learning. Teachers are under pressure in reaching the standard objectives and fear that schools using ICT will be less performing than traditional schools.

Conditions to maximise ICT impact

Studies under review identified important relationships that could maximise impact either in the area of learning outcomes or teaching. They point to the necessary conditions for transforming the potential of ICT into concrete outcomes for both areas:

- Schools with higher levels of e-maturity demonstrate a more rapid increase in performance scores than those with lower levels (Becta, 2006).
- ICT investment impacts on educational standards only when there is fertile background for making efficient use of it (Machin, 2006).
- The greatest impact is found in relation to teachers who are experienced users and who from the start had already come far with the integration of ICT in their teaching (Ramboll, 2006).
- Schools with good ICT resources also achieve better results [49];
- Embedded ICT over a longer period of time has lead to more use of ICT by teachers and considerably increased their confidence in using ICT (Ramboll 2006).
- Teachers that assess to experience a more positive impact of ICT are most likely to be found in schools where headmasters have used ICT to support the development of the school's values and goals (Ramboll, 2006).
- Some of the best examples of the use of ICT were where lessons moved through different modes of teacher-pupil interaction which involved both in a variety of roles and where intended and actual use coincided (Comber, 2002).
- Teachers, who report a great positive impact of ICT, think that ICT improves pupil performance, consider ICT as a tool to support both subject content and pedagogy and think ICT has an impact on teaching. They use ICT in the most project-oriented, collaborative and most experimental way (Ramboll 2006).
- Broadband plays an important role in integrating ICT in schools, affecting teaching and learning in several ways. **Embedded, reliable and high-capacity broadband in the classroom** has increased the quality and

[49] However, this evidence is not yet consistent and extensive.

quantity of educational activities that can be undertaken (Underwood 2005).

10. 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? [50]
   - 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.
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?

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

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.[51] 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. How can we speed up the change processes in schools? Changes in education are long term changes.

[51] 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.

11. Recommendations

Based on the research findings as outlined in chapter 6, 7, 8, and the discussion of emerging questions resulting from the evidence in chapter 10, the authors formulated recommendations for future actions to achieve greater impact in both areas of teaching and learning. The ICT cluster and external experts gave concrete inputs to the recommendations in terms of their content and ranking. These should yield to a concrete list of action at national and European level.

Policy makers (national, regional and school level)

1. Plan for transformation and for ICT

Support the transformation process and management of change, of which ICT is an enabler and amplifier. The key word is transformation. If the organisational and institutional context does not support new working methods, educational practices will not change. Taking into account that most teachers embrace new technologies in a step by step process, systematically but slowly, any change should be supplemented by process management and connected to realistic visions. This means allowing schools to experiment within given boundaries. The same holds true for more drastic changes, which are more difficult to achieve.

2. Include new competencies in the curricula and in assessment schemes

Most of the reviewed studies show that ICT impacts on competency development – specifically team work, independent learning and higher order thinking skills – that are not yet recognised by many education systems. These competencies should be formally included in the curricula and ways of assessing them explored. They are important outcomes of a new and changed educational context.

3. Implement new forms of continuous professional development in a workplace environment and as part of a culture of lifelong and peer learning

New approaches to teacher training should be much more related to the concept of lifelong learning, knowledge sharing and peer learning. To be confident teachers must be able to upgrade their ICT skills and gain more pedagogical knowledge and this in a much more active way than previously. Teachers have to become active shapers of their own learning process which requires a professional environment and culture that allows teachers to do so. An experimental approach using ICT in everyday practice is an important factor in increasing teachers' pedagogical competence. Training programmes should be more school-based and adapted to the particular needs of teachers and fit to personal and subject specific needs, or project related needs. Continuous professional development should be in the foreground enabling teachers to learn how to upgrade their skills. Up-front sessions should be replaced by practice oriented projects in the practical working environment. Initial teacher training for ICT, not tackled in this review, is also seen as an important area for improvement in the future, next to concrete measure for improving in service teacher training.

4. Build up a clear political will and invest in ICT consolidation

The countries analysed in this study did benefit from high ICT investments and a strong political will to foster ICT in education. Without that wider impact on teaching and learning can not be achieved. The evidence showing that ICT impacts most with e-mature schools and teachers suggests that there is a take-off or tipping point in ICT use. Before that point, little change appears to be happening and investments seem to have little pay-off. Once the change occurs the benefits accrue. Work towards ensuring the majority of schools (80 per cent by 2010 for example), not just the early adopters, reach the point of e-maturity. One way forward is to make use of the existing potential of e-confident users

(students, teachers, head teachers, ICT support) in and around schools (parents, community centres, librarians, museums).

A second important issue for ICT consolidation is the focus on content and support services in schools. The value of access to good interactive digital content is essential for the successful implementation of ICT. The lack of access to appropriate digital content, related copyright issues and costs of licenses was identified as a major barrier for ICT use in schools and more actions and solutions are needed on national and European level. One recommendation is to join together the paper-based and digital content market, and harmonising licences approaches and accreditation of content. There are ways to reconcile aggregated purchases while maintaining autonomy and independence of individual institutions (e.g. a framework agreement based on actual usage). Sufficient ICT support services and maintenance contracts ensuring quality equipment for schools are indispensable conditions to achieve wider impact with ICT in teaching and learning.

5. Motivate and reward teachers to use ICT

As the survey has shown, in addition to access to infrastructure and content and having the requisite skills, teachers' motivation is a critical factor in ICT adoption, and this is often neglected. On a European level, there are considerable discrepancies with regards to motivating teachers. Actions should be built into policies that encourage teachers to use ICT more – and more effectively. Policies in this area should include measures raising the confidence levels of teachers (sufficient on-site support, appropriate in-service and initial teacher training in ICT) but also means of incentivising, recognising and rewarding the use of ICT (such as appraisal schemes, making good ICT use part of career paths, or time benefits for teachers engaged in ICT related projects).

Schools

6. Integrate the ICT strategy into the school's overall strategies

As the latest evidence confirms teachers that assess to experience a more positive impact of ICT are most likely to be found in schools where headmasters have used ICT to support the development of the school's values and goals. If the ICT strategy is integrated into the school's overall strategy ICT has the greatest potential to act as a catalyst for change. Furthermore this overall strategy needs to be developed and evaluated by all school actors and not only by the headmaster in collaboration with the ICT coordinator, thus establishing a culture of collaboration and commitment and making it more likely that the policy is actually solving a problem that teachers and students are facing. Communicate about your objectives with teachers, students and parents in order to take away wrong expectations, unnecessary fears and manage doubts.

7. Transform positive attitudes towards ICT into efficient widespread practice

Schools should capitalise on positive attitudes. To achieve greater impact it is important that teachers underpin ICT use with a pedagogical approach. There seems to be a mismatch between the potential of ICT for learning and the actual teaching approach of teachers. The majority of teachers think that ICT can improve learning outcomes, but they think that ICT has little or no impact on their methodology. This could be achieved by hand on practical training, providing easy to use ICT based materials, peer learning and peer sharing of experiences,

securing reliable infrastructure, triggering teachers knowledge in their subject, pupil motivation, and easy access to research findings. [52]

Research and Development

8. Consider context-sensitive and process- oriented research methods
In such a complex field as education and pedagogy, qualitative methods are necessary to investigate impacts. There is a need to go beyond pure observations and evaluate more concretely school contexts, learning situations and teaching processes to show under which circumstances ICT based activities can enhance learning and improve skills. This requires some degree of qualitative interpretation, in order to evaluate the causes of impact which have been observed. A holistic approach to identify impact is needed. What works for whom in what circumstances is what policy makers/ shapers need to know.

Apart from research that shows benefit for ICT in subject, research should be conducted to find out how ICT can positively influence the learning process. How ICT can support certain learning processes and thus raise attainment will require a process oriented approach in evaluating impact of ICT for the future. Further research is needed into detecting the impact of ICT on these wider competencies and innovative pedagogical practices behind them.

9. Create closer links between research and practice
More fundamental research, small scale, focussed research on specific ICT tools should be combined with research which is much more closely linked to practice: Ways forward are to develop a critical and reflective attitude amongst teachers or teachers carrying out research themselves (coached by researchers) and involving schools in defining research questions.

Furthermore the results of research should be made available to practitioners in a way that it is useful for them (evidence leaflets, easy access to research evidence and appropriate ways of communicating main research findings).

10. Encourage more qualitative trans-national research into ICT impact
This paper has gathered evidence relating to the impact of ICT on learning outcomes, teachers and teaching that has largely arisen in national contexts (with the exception of the e-learning Nordic study). It has been assumed that the results are likely to apply in other countries but this may not be true. International comparisons should move beyond baseline data and give more qualitative insights into ICT use by learners but even more by teachers.

11. Make national research into ICT impact accessible
As the review shows there is a geographical imbalance of national evidence of ICT impact across Europe. Either there is a lack of the relevant research and/ or the research is difficult to access because of language and fragmentation of research, specifically in federal systems. It is therefore recommended to:

Set up mechanisms on European and national level that allow us to know better the results of such research, e.g. set up a repository of abstracts of national, European and international research. This should include various types of research small and large scale.

12. Rethink the approach to evidence and its relation to decision making

[52] Ernist ICT school portraits (EUN, 2004)

The overview of the different research approaches already taken in that field can help policy makers to decide on a specific national approach suited to their education goals and context. However, policy makers should consider the following: 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. ICT can be used in a variety of ways; the benefits and impact of ICT therefore vary likewise. The review has shown that impact on education is heavily dependent on the political objectives and hardly measurable within traditional educational standards. Research should therefore not focus on ICT alone, but include wider topics such as innovation and prospective studies and find instruments to capture and detect unexpected results and processes.

13. Support both large and small scale studies on ICT impact and base decisions on both quantitative and qualitative evidence

Any quantitative data from large scale national studies should be complemented with qualitative data arising from smaller scale studies or research projects. The advantage of small case studies is that they are context depended which large national/ international studies often fail to deliver. In turn, any qualitative evidence should be enhanced with quantitative data arising from independent, critical, longitudinal and large-scale studies with experimental and control groups to test the claims made for pedagogy, e.g. a raise in attainment or an endured change. A clear advantage of international large-scale studies is that they are independent from national contexts and policy goals.

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Note: Weblinks were accessed between June and December 2006.

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Annex 1 Index of core review studies

Title of Study	Country	Short Reference	Number 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**

Annex 2 Overview of impact areas by study

Reviewed Studies (I)	Comber (2002)	Harrison (2002)	Higgins (2005)	Eurydice (2005)	Eurydice (2004)	Kessel (2005)	Machin (2006)	ITU (2004)
Scope	15 schools	60 schools 700 pupils	122 primary schools 68 teachers 72 pupils 184 lesson observations	Primary schools (150 schools per target population) Secondary schools (OECD, Pisa 91091 students)	Primary schools (150 schools per target population) Secondary schools (OECD, Pisa 91091 students)			120 schools
Timeframe	Two school terms	1999-2002	2002-2005	Pirls data from 2000/2001 PISA results 2003	Pirls data from 2000/2001 PISA results 2003	2000-2005	1999-2003	1999-2003
Methods of measuring impacts								
Questionnaires and interviews of students'/teachers'/parents' perceptions- assessing impact	x		x			x		x
Lesson observations	x		x					x
Use of ICT and relative gains in national tests (statistical analysis)		x	x					
Spending on ICT, changes in policy and pupil achievement (statistical analysis)							x	
Analysis of national/ international data bases				x	x	x	x	
Case study analysis	x							
Records of ICT use			x					
Maturity Models								
Action research								

Identified impact areas for learning and learners								
Improvement in student's subject related performance			x				X (primary)	
Perceived improvement on learning and outcomes						x		x
Improvement in student's basic skills (e.g. writing)			x					x
ICT supports research skills/higher order skills	x							x
Improvements in behaviour/attention/attendance	x		x					
Increased student's motivation and engagement	x	x	x					
Increased learner independence								x
Differentiation			x					x
Increased collaboration and cooperation among students						x		

Identified impact areas for teachers and teaching								
Increased enthusiasm and confidence			x					x
Increased efficiency/ collaboration/planning			x			x		x
Increased /positive effects on classroom interaction	x		x					
Increased skills						x		
ICT to enhance teaching	x		x					
New pedagogical practices (ICT to enhance learning process) ICT to enhance transferable skills (problem solving)	x		x					

Change in teachers' role	x							x

Other impact areas								
Home use of ICT	x			x				
Leadership/Management								x
Collaboration between schools								x
School development	x							

Reviewed Studies (II)	OECD (2004)	Ramboll Management (2005)	Ramboll Management (2006)	Toots (2004)	Underwood (2006)	Underwood (2005)	EUN (2004)	Empirica (2006)
Scope	41 countries, more than 250000 students participating in PISA 2003	~ 515 schools, 17 case studies	224 Nordic schools, 800 interviews, 12 school visits	366 teachers, 98 schools (2000) 305 teachers, 84 schools (2004)	28 schools 3 Further Education colleagues, 61 action research studies	592 primary schools 201 secondary schools	20 school portraits	10000 head teachers; 20000 classroom teachers
Timeframe				2000 and 2004	2002-2006			Spring 2006
Methods of measuring impacts								
Questionnaires and interviews of students'/teachers'/parents' perceptions- assessing impact		x	x	x	x	x	x	x
Lesson observations							x	
Use of ICT and relative gains in national tests					x	x		

(statistical analysis)								
Spending on ICT, changes in policy and pupil achievement (statistical analysis)								
Analysis of national/international databases	x							
Case study analysis		x				x	x	
Records of ICT use								
Maturity models					x			
Action research					x			

Identified impact areas for learning and learners								
Improvement in student's subject related performance	x				x	x		
Perceived improvement on learning and outcomes			x				x	
Improvement in student's basic skills (e.g. writing)			x					
ICT supports research skills/higher order skills						x	x	
Improvements in behaviour/attention attendance					x			
Increased student's motivation and engagement			x		x	x	x	x
Increased learner independence			x					
Differentiation			x		x	x		
Increased collaboration and cooperation among students								

Identified impact areas for teachers and teaching								
Increased enthusiasm and confidence		x	x		x	x		
Increased efficiency/ collaboration/planning		x		x	x	x	x	x
Increased /positive effects on classroom interaction							x	
Increased skills/ staff development		x		x	x	x		x
ICT to enhance teaching			x	x	x		x	
New pedagogical practices (ICT to enhance learning process) ICT to enhance transferable skills (problem solving) ICT for assessment				x	x		x	
Change in teacher's role							x	

Other impact areas								
Home use of ICT	x			x	x			
Leadership					x			
Collaboration between schools					x			
School development		x	x				x	

European Schoolnet (EUN) is a not-for-profit organisation funded by education ministries in Europe dedicated to supporting schools in the best use of technology in learning, promoting the European dimension in schools and education and improving and raising the quality of education in Europe.

European Schoolnet is the leader in the field of school collaboration in Europe. It has ten years of successful experience in helping schools achieve effective use of new technologies, place European issues at the heart of schooling and equip youngsters and teachers with the skills to achieve in the knowledge society.

European Schoolnet collaborates with the 28 Ministries of Education of the EUN Consortium to identify new priorities in education in Europe. Through a series of successful projects, initiatives and partnerships, European Schoolnet enables peers from ministries to debate and exchange lessons learned in ICT in education policy.

The EUN consortium has been involved in many successful collaborative pan-European projects, offers a range of services, has produced numerous publications and organises many workshops and seminars in the three strands of EUN: School networking and services; Knowledge building on ICT Policy and practice; and Interoperability and Content exchange.

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The full report is available online at:
http://insight.eun.org/ww/en/pub/insight/misc/specialreports/impact_study.htm

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