

Effective use of ICT in schools

Analysis of international research



MYNDIGHETEN FÖR
SKOLUTVECKLING

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Foreword

ICT in schools has been the object of various initiatives for a relatively long period of time; the question is if and under which circumstances ICT utilization in schools can contribute to improved attainment of objectives. The Swedish National Agency for School Improvement has recently introduced several initiatives to increase awareness of the benefits ICT can offer schools.

In the analysis, Torbjörn Skarin, analyst and a senior adviser at the research and consultancy company Metamatrix, was tasked by the Swedish National Agency for School Improvement to review a large number of studies and research reports within the area of ICT in school. The selection of studies to be analyzed was made based on an overview of existing knowledge on the benefits ICT offers to schools that the author of the report had previously performed on behalf of the agency. Based on both Swedish and international research, the aim of the analysis is to gain an idea of under what circumstances ICT/technology can positively contribute to learning and fulfilment of the objectives.

The analysis, which was solely performed by the author, shows that there is no automatic correlation between ICT usage and results. However, ICT usage set in a pedagogical context shows that there is a clearly positive relationship between ICT usage and results (measurable and/or perceived). Some of the factors named as reasons for the results are increased motivation, reinforced conceptual understanding and increased individualization.

The author emphasizes a number of circumstances that must be in place for the positive effects of various initiatives to be attained. Among other things, strategies for how ICT should be used in schools must exist on both national and local levels. The author also indicates a need for objectives that can be followed up and self-evaluation instruments that schools can use in their development work.

The selection of studies was limited to those that include involvement of some kind on a national level in order to ascertain which factors impact on the system. The report has not put specific emphasis on studies that focus on students with special needs, for which ICT is naturally an important element. However, the author of the report indicates one factor that has more general significance: accessibility. We currently lack reliable data regarding the number of students per computer in Swedish schools, but have been able to observe that differences between municipalities and/or schools seem to be increasing. In other words, students do not have equal access. Municipalities and schools also choose different strategies for coping with the needs schools have for equipment; for example, initiatives involving one laptop computer per student seem to be gaining ground. The individuals responsible for the project at the Swedish National Agency for School Improvement are Peter Karlberg, Expert, and Christina Szekely, Director of Education.

We would like to thank Vanessa Pittard, Director- E-strategy at Becta, the British agency for ICT in education, for the financial support of the translation of this report from Swedish to English. It is important to collaborate and to share knowledge between countries and between research organizations. It is also equally important to make research more available and accessible to practitioners within the education community. We hope that this report will be helpful in understanding the current and the future challenges and opportunities with ICT in schools.

Stockholm/Sweden, February 2008

Suss Forssman Thullberg
Head of department for Information and Communication

Summary

Since the beginning of the 1990s, the Nordic countries have invested a great deal of time and personnel resources in order to take advantage of ICT in education and learning. However, there has been a lack of measurable evidence that clearly shows the practical results of these investments. In order to increase the effects of ICT as a teaching tool in schools, a stable knowledge base is needed upon which to base future initiatives. It is important to analyse relevant studies and reports to ascertain, in the next step, what encourages or restrains development.

Metamatrix, a Swedish research and consulting company, was tasked by the Swedish National Agency for School Improvement with analysing a large number of studies and research reports within the area of ICT in schools. The assignment involved performing analyses and reaching conclusions that focus on the correlation between initiatives and student development and results and, in a structured manner, to show how different initiatives impact on learning and skills acquisition. The analysis was to be based on a synthesis of the conclusions that each study had arrived at and, if possible, offer general recommendations for working with technology in schools effectively.

Impact on student development and learning

An extensive review of European studies on the impact ICT has in schools indicates a number of important and comprehensive advantages of using ICT in learning. The advantages that have been emphasised include increased student motivation and level of skills, an increased level of independence and development of collaboration. Increased levels of student motivation result in increased levels of attention and involvement during lessons, which encourages learning.

Individualised learning is also encouraged when ICT is used – students work independently at their own pace, based on their own personal needs. Many studies indicate that ICT also helps improve student development and skills, and thereby attain objectives to a greater extent. In certain situations, however, ICT use itself impacts on learning.

However, the studies show that the technology itself should not be the sole focus in terms of gaining advantages; rather, efforts must also be focused on using the technology when it is linked to a pedagogical model.

The overall picture clearly indicates that ICT has a positive effect on learning (both measurable and perceived effects) and on performance in specific subjects. An extensive British survey of the research and studies in the area clearly shows a positive correlation between ICT and learning in basically all subjects included in the national curriculum; the correlation was most clear in English, mathematics and science. A great deal of investment has also been made in subject-related digital learning resources in these subjects to encourage learning and education.

Studies also show a strong connection between the way ICT is used and student learning. This indicates that an important component is the teacher and his or her pedagogical attitude towards ICT. It is, however, somewhat difficult to demonstrate the direct correlation due to the difficulty of drawing general conclusions linked to a certain situation, a certain type of usage or a specific teaching approach. The more embedded or integrated a specific technology is, the greater the impact, which is an important aspect in terms of how ICT in learning should be approached.

One report draws the conclusion that the combined effects of increased investments in ICT plus a positive school environment create positive effects in primary school. A large number of studies and reports have found clear indications that ICT in learning increases the level of student motivation and involvement. However, the effects of increased motivation are often found in teaching that focuses on learning as a process rather than on resolving a specific task. ICT use is most effective when students feel that the task fulfils its purpose and when ICT is integrated into the learning process in a manner that reinforces and develops learning so that the effects of teaching are more long term.

There are clear indications that ICT has a positive impact on learning and student performance when it becomes an integrated element in the classroom and teaching. Several studies show clear indications that visual digital technology (such as animation, simulation and moving images) involves students and reinforces conceptual understanding. ICT use also encourages development from a teacher-focused or teacher-led model to a more student-focused model in which students work together, make their own decisions and take an active role in learning.

Ambient and influencing factors

A Nordic study shows that students, teachers and parents feel that ICT has a positive impact in terms of improved learning. The study indicates that there is a correlation between accessibility to computers with Internet connections and impact on learning. It is important that schools and teachers actively incorporate ICT in instruction and teaching methods.

ICT should also be incorporated into the everyday work of schools, including co-operation between the home and school. Research shows that when ICT is used in a flexible manner to extend learning beyond the confines of the school, that students are able to refine and enrich their school work. One out of three teachers in the Nordic countries, however, feels like their lack of knowledge limits their ability to use ICT more in their teaching and when planning tasks and exercises. An OECD report also clearly indicates that the extent to which students have access to computers and their level of self-confidence when using computers affect their results.

Teacher and student use of laptop computers in the classroom has been the focus of a large number of studies and evaluations related to the impact on learning. The conclusions from the studies show that laptop computers increase the level of student motivation and involve students to a greater extent, especially when they are used with interactive whiteboards. Mobile technology offers additional options in terms of learning, and student tools can be adapted to individual learning styles and preferences.

The national evaluation of the IT i Skolan (ITiS) programme draws the conclusion that ICT as a thought-provoking teaching tool increases the level of teacher skills and development work which has served to propel reflection and thought forward as well as inspired new working methods. Personal approaches to teaching, however, also play an important role in terms of teachers being able to create learning opportunities that are communicated via technology. For example, teachers need extensive knowledge of ICT in order to select appropriate learning resources. They also need to understand how to integrate ICT into lessons and perhaps also how to develop new methods in order to achieve an increased level of integration. Thus, new methods are required when using ICT, and in some instances teachers need to develop their role as sounding board and “enabler”.

Teachers must also take on a leadership role in terms of planning, preparing and following up lessons. Research shows that an increased level of lesson planning helps students to become more focused, which results in an improved learning effect. Research shows that ICT use has a more direct impact on student attainment when the teacher uses his or her knowledge – both in terms of the subject itself and understanding of how students learn in the subject.

One critical factor related to effective use of ICT is the existence of a strategy for ICT use that is linked to the pedagogical work in schools. Such a strategy should take future, long-term development into consideration and include methods for measuring and following up development in relation to identified milestones and objectives. Significant investments have been made in ICT, both on local and regional levels; however, there has been a lack of clear criteria for measuring success and following up results in a structured manner.

Strategic proposals for improved learning in school

Based on the conclusions of the studies reviewed for this report, a number of strategic proposals can be formulated regarding the long-term efforts related to creating a school for the future – a school in which ICT is perceived as synonymous with pedagogical development and creative learning. These proposals are the author's recommendations regarding which initiatives should be considered as the most central in terms of ICT use having a clear and positive impact on instruction and learning.

The strategic proposals for improved learning in school include:

- a national plan for how technology should be used in schools
- increased level of ICT access and integration
- a model for measuring and encouraging e-maturity and digital competence
- increased focus on using learning resources and new working methods.

The author of this report makes no claim that the analysis is all-encompassing or that the studies presented in the report are completely unambiguous in their conclusions. The aim is for the report to help interested readers gain a more in-depth understanding of and insight into effective use of technology in schools, which will hopefully serve as inspiration for future initiatives in the area.

1. Background

The Nordic countries have long been considered world leaders in terms of using ICT¹ in learning. According to the study *Benchmarking Access and Use of ICT*,² all Swedish schools have access to computers and the Internet, and just over 90 per cent of teachers have used a computer during a lesson during the course of one year. The study, which was initiated by the European Commission, indicates that Sweden is third out of 27 countries in terms of how ICT is used during lessons in European schools. One problem, however, is that the majority of teachers in Sweden use computers less than 10 per cent of lesson time.

About half of all teachers in Sweden believe that the greatest difficulty in terms of using ICT in schools is lack of access to computers. Only one out of six students in schools has access to a computer with an Internet connection, which means that Sweden is in sixth place in Europe in this area. Most teachers in Sweden do not feel like they have sufficient knowledge of ICT, and about half of the teachers do not believe that ICT encourages learning. When considering the combination of adequate access to ICT and computers, knowledge of ICT and motivation to use ICT in schools, Sweden is almost last on the list. Taken together, this creates a complex image of the approach to and use of ICT in Swedish schools.

Since the beginning of the 1990s, the Nordic countries have invested a great deal of time and personnel resources to be able to take advantage of ICT in education and learning. However, there has been a lack of measurable and clear evidence that shows the practical results of these investments. According to *The ICT Impact Report*³ from European Schoolnet, there are relatively few European studies that have looked into the practical effects of using ICT in schools. However, the Nordic study called *E-learning Nordic 2006*⁴ is one European study that has focused on the benefits of using ICT in schools. This study indicates that ICT has a positive effect on the overall objectives in schools in terms of improved learning and development. In order to take advantage of the opportunities that arise, however, ICT must be used in a sensible and well-considered manner.

Introductory overview of existing knowledge as the basis

In order to form a basis for continued development of ICT as a tool used in schools, the Swedish National Agency for School Improvement performed an international overview of existing knowledge⁵ in order to take stock of major studies and research reports within the area of ICT in schools. Focus was on reports and studies that researched the correlation between ICT-related initiatives in schools and student benefit expressed as positive effects on results and development. Some of the elements of student development that were of particular interest for the overview included development of student grades, reading skills, motivation, networking and the collaboration linked to these areas.

The overview included studies and reports that concerned students in compulsory and upper secondary school (or the equivalent). It was limited to studies and reports that concentrated on initiatives in school systems that were considered comparable, for example in Europe, within the OECD, etc. The Swedish National Agency for Education (Skolverket) defined comparable or equivalent school system in an earlier report as⁶ all students being given the same opportunity and access to education, no matter social background and finan-

1. ICT is used in this report as an umbrella term for all types of information and communication technologies

2. Empirica, 2006, *Benchmarking Access and Use of ICT*

3. Balanskat, Blamire, Kefala, 2006, *The ICT Impact Report*, European Schoolnet

4. Ramböll Management, 2006, *E-learning Nordic 2006*

5. Skarin, 2007, *Internationell forskningsöversikt kring IT i skolan*, The Swedish National Agency for School Improvement

6. The Swedish National Agency for Education, 2004, *Sammanfattning av rapport 254 (PISA 2003)*

cial circumstances. Only published and free-access reports were included in the overview, that is only completed studies were included. Some of the sources that were utilised include relevant authorities, research institutes, universities in different countries, official forums and networks within the area, the European Commission, the Google Scholar search engine and other similar search services.

A large number of studies and reports were reviewed and assessed during the course of the overview and a number of the studies were selected based on their scope, focus, scientific status and demonstrated impact on learning and students. The effects on learning and student development were divided into:

- measurable effects can be produced through statistical analysis or by comparing the before and after of various initiatives and
- perceived effects can be the result of an interview or a questionnaire in which an attempt is made to evaluate the effects of the initiative.

The overview of existing knowledge does not claim to be all-encompassing or to have represented the only image of ICT and its impact on learning and development in schools. For example, there are several studies in the United Kingdom that were not selected for use in this survey since the issues dealt with in them and the conclusions that were drawn had already been considered in other studies. There are also studies that were not entirely unambiguous in their conclusions; some of these studies were not selected for this reason, while others were chosen nevertheless. There are also examples of studies in which ICT was not shown to create any clear positive effects on education and learning, and a few of the studies indicated some negative effects.

The reason for intentionally focusing on the positive examples and their positive effects is to clarify the possible benefits and the impact of ICT in schools. The intention was also to perform an analysis of what makes a specific project or initiative within the area successful. A total of 35 different studies and research reports are presented in this overview.

Continued analysis of initiatives and effects

In order to increase the effects of ICT as a learning tool in schools, a stable knowledge base is needed upon which to base continued initiatives. It is important to analyse relevant studies and reports to enable conclusions to be drawn regarding which components encourage development of learning and which ones restrain it. It is important to make a distinction between outcome and effect:

- Outcome refers to the direct product of performed activities, for example the number of purchased computers or the number of lessons in which ICT is used.
- Effect refers to the possible changes that may take place as a result of these initiatives, for example positive development of learning.

The correlation between input, activity, output and effect can be illustrated as in the figure below. The image shows how using ICT in schools can be initiated as a result of a conscious effort or change to existing teaching methods. When the effects of an initiative that is intended to increase the learning capability of students are measured according to this model, a strong correlation between ICT use in schools and learning can be discerned. When the effects of an initiative are analysed and assessed, however, it is necessary to link the effects to the overall aim or objective of the initiative. The aim of the Nordic countries when using ICT in schools is to improve learning.

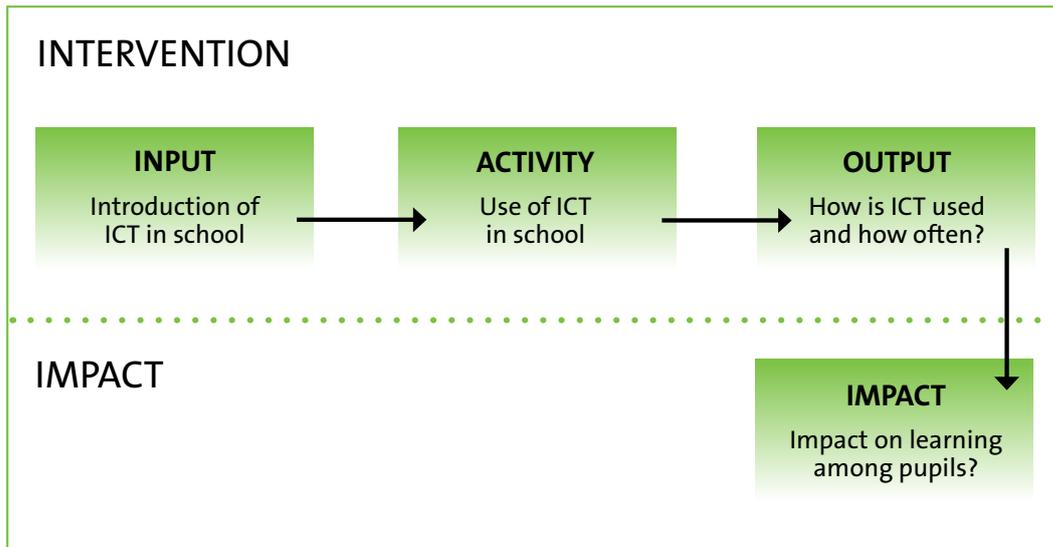


Figure 1. Ramböll Management, 2006, E-learning Nordic 2006, part of Figure 1, model of the relationship between intervention and impact.

Metamatrix, a Swedish research and consulting company, was tasked by the Swedish National Agency for School Improvement with performing an in-depth analysis based on a selection of studies and reports from the previous overview of international studies and research reports within the area of ICT in schools. Twenty-one reports were selected based on their scope, focus, method, current interest and clarity in terms of their measurable or perceived effects. The analyses and conclusions were to focus on the correlation between initiatives and student development and results and, in a structured manner, show how different initiatives affect learning and skills acquisition. The analysis was also to be based on a synthesis of the conclusions that each study had arrived at.

A dialogue with experts on national and international levels was carried on during the course of the assignment to stay abreast of ongoing activities and new research that might be relevant for the analysis.

The analysis aims to increase understanding of what encourages or restrains student acquisition of knowledge in terms of ICT in schools. The analysis will hopefully serve as inspiration for developing new programmes and initiatives within the area.

2. Current focus on studies and research

There are several studies available related to how technology and ICT are used to encourage learning in schools. ICT use and new technology in part pertain to learning and operating a computer and its various applications, and in part to using technology as a tool to support and encourage the learning process and teaching. Focused efforts including studies and research in the area are currently being pursued in several countries. A few examples are presented below to illustrate how work is being pursued and which issues are most relevant in each of the countries or regions.

Sweden

Several major initiatives were implemented in the 1990s to develop ICT use in Swedish schools, for example building up the Swedish schoolnet, the IT i Skolan programme (ITiS⁷), initiatives from the Knowledge Foundation (KK-stiftelsen) and collaboration with in the European Schoolnet.⁸

In conjunction with the Knowledge Foundation's⁹ initiatives to promote ICT usage in schools and a new generation of teaching materials that was produced in the 1990s, it became clear that there was no relevant research available on learning and ICT in Sweden. In order to help stimulate interest, the Knowledge Foundation decided, at the end of the 1990s, to initiate and support research within the area of ICT didactics and ICT and learning.

Swedish research surveys within the area of ICT and learning have been produced by the Knowledge Foundation on a number of occasions. One of these research surveys from 2005¹⁰ shows that just over 35 per cent of all research within the area pertains to studies on using teaching tools and distance education as well as flexible learning. Almost half of these research projects are entirely or partially financed by the Knowledge Foundation or the Swedish Research Council.

A research survey from 2006¹¹ shows that the number of new research projects within ICT and learning have gradually diminished since 2002. The majority of Swedish research is concentrated on individual or group levels or on school or municipality levels; few studies focus on the national level. In terms of roles that have been studied in Swedish research, most studies have focused on students or teachers, and relatively few have studied the role of school leaders. The large-scale projects that have been carried out in Sweden have been initiated by the Government via the Ministry of Education and Research, various educational agencies and the Knowledge Foundation.

Norway

The National Network for IT Research and Competence in Education (ITU) has a central role in Norwegian research that pertains to ICT in schools. ITU is a national research and development unit that works on national and international levels. The network's focus for the period between 2004 and 2008 is on the national knowledge structure for digital learning and competence. One of ITU's studies is called ITU Monitor. It is a longitudinal survey that aims in part to ascertain to what degree ICT is integrated into education in a positive pedagogical manner and in part to perform a general survey of ICT use in specific subjects and general ICT usage in teaching.

7. Delegationen för IT i skolan

8. Ministry of Education and Research, 2002, Nästa steg, delrapport från Arbetsgruppen för ny nationell IT-strategi för skolan, DS 2002:19

9. The Knowledge Foundation

10. Metamatrix, 2005, Forskningsöversikt IT och lärande, The Knowledge Foundation

11. Metamatrix, 2006, IT och lärande en översikt av aktuell forskning inom IT och lärande, The Knowledge Foundation

Denmark

Learning Lab Denmark performs research into learning and skills development in a knowledge society. The aim is to create useful research-based knowledge. A frequent point of departure is existing practical knowledge. Development of new methods and medias for learning is one of their areas of focus; the area includes learning games and ICT use.

The Government in Denmark is investing heavily in e-learning. The country's new three-year national strategy for e-learning focuses on taking advantage of the knowledge young people have in ICT use in order to develop and renew education. The starting point lies in young people's usage of media outside school, and media researchers are being involved in order to find new solutions.

Finland

The Centre for Research on Networked Learning and Knowledge Building is located in Finland. The centre aims to increase quality in Finnish education through qualitative research into computer-supported and collaborative learning specifically, and ICT usage generally. The centre performs studies associated with collaborative learning. It also analyses methods and practical experiences of ICT use in educational institutions, universities and companies.

United Kingdom

The UK has focused on the area of ICT and learning for a long period of time, and the British government has justified its large investments into ICT with the claim that it is crucial in terms of improving levels of education among citizens.¹²

The UK has had a strategy for ICT in education since 2005¹³. Its aim is to ensure that ICT lives up to its potential in terms of changing education and that it supports increased levels of efficiency and choice within the educational system. There are a large number of research reports and studies within the area of ICT and learning, for example from the British authorities Becta¹⁴ and Ofsted¹⁵ and the Department for Education and Skills (DfES), in addition to independent research institutes and groups. This type of research is often conducted by using analyses of national and international statistics, large-scale questionnaires and studies, data obtained from inspections and evaluations and through systematic analyses and literature surveys within the area.

USA

Many American studies and research projects focus on use of and access to various types of laptop and handheld computers. Some of the studies are geographically delimited and have been used as the basis upon which to introduce various solutions on a broad basis. They have also been used to evaluate previous projects. There are a number of studies that analyse computer-supported instructions, use in teaching, technology use in general, etc. The entities that generally conduct major studies in the area are states, universities, research institutes and private analysis companies.

Other European/OECD countries

A number of studies that focus on ICT in schools and learning have been performed in the rest of Europe and in the OECD countries. Several reports are linked to the PISA study,¹⁶ while others are large scale, international questionnaire surveys that measure and compare student access to and use of ICT in and out of school. Several of the large studies analyse existing literature, research, questionnaire surveys and other studies within the EU and OECD.¹⁷ The English school authority Becta has also produced a number of studies and analyses that consider ICT use in schools from a European perspective.

12. Minister of Education Ruth Beth, speech at BETT, annual conference on education and technology, London, 2005

13. Department For Education and Skills, 2005, Harnessing technology: transforming learning and children's services

14. British Educational Communications and Technology Agency

15. Office for Standards in Education

16. The OECD Programme for International Student Assessment

17. OECD Organisation for Economic Co-operation and Development

Other countries and regions

There are a number of national and regional studies from other countries in, for example, Africa and Asia that look into ICT in schools and the more specific effects of ICT in schools. For example, according to an Indian study, there is an interesting correlation between ICT investments and impact in terms of how grades develop in mathematics for students living in slum areas.¹⁸ There are also interesting, positive correlations between ICT in the classroom and how teacher trainers' sense of involvement and motivation develops according to a study from Kenya.¹⁹ However, it is difficult to draw any far-reaching conclusions from some of these studies since they are based on educational systems that are not directly comparable to those found in Europe.

18. Banerjee et al, 2003, Remedying Education, Evidence from Two Randomized Experiments in India

19. Janssens-Bevernage, 2004, Integrating ICT in teacher training a case study of the learning resource centre at the Kenya Technical Teachers College

3. Selection of studies from various countries

The author of this analysis selected 21 reports and studies from the 35 reports that were included in the previous overview of existing knowledge. The selection was based on the studies' scope, focus, method, current interest and clarity in terms of measurable or perceived effects. The 21 reports form the basis for more in-depth analysis of international studies and research reports within the area of ICT in schools. A brief summary of the studies including their focus, scope and results follow.

Of the selected reports, 4 come from the Nordic countries, 10 from the UK, 2 from the U.S. and 5 from the rest of Europe/OECD countries. The distribution of countries and regions was on approximately the same level in the previous overview of existing knowledge as in this selection. The summary includes information on the name of the report, the year it was published, its aim, methods and results. A link to the report in question is available in the list of references.

The studies are grouped by the country/region they focus upon, and they are organised chronologically last to first. Readers who are interested in more in-depth knowledge and insight into specific studies are encouraged to refer to the sources found in the list of references.

In order to allow readers to make comparisons between studies in different countries, the British education levels primary school and secondary school are combined into an umbrella term, compulsory school level, when both levels are referred to. Primary or secondary school are used when relevant. The division of various age groups (key stages) that exist in the British school system are indicated as the specific ages that the levels comprise.

Nordic countries

E-learning Nordic 2006

E-learning Nordic 2006 studies the effects of ICT in learning. The study was conducted in Denmark, Finland, Norway and Sweden. A total of 8,000 school leaders, teachers, students and parents responded to a questionnaire regarding how ICT affects learning and school work.

ICT is experienced as having a positive effect on learning. The positive results primarily pertain to student performance in specific subjects, but results were also positive in terms of general reading and writing development. ICT also has a positive impact on overall objectives and student performance at schools. Teachers in particular say that ICT offers increased opportunities to individualise learning based on the prerequisites and needs of different students. However, ICT must be used in a sensible and well-considered manner for the opportunities it offers to be taken advantage of.

IT i skolan 2006 – attitydundersökning, ICT in schools 2006 – attitude survey

The Knowledge Foundation has examined student, teacher and school leader attitudes to ICT use in schools on a continuous basis. A recurring study called IT i skolan queries 1,200 teachers and 600 headmasters in compulsory and upper secondary schools as well as 1,200 upper secondary school students. The most recent study was performed in 2006; roughly 3,000 telephone interviews were performed. The aim of the studies is for the Knowledge Foundation to learn which needs and opportunities for development can form the basis for new initiatives within the area.

The most recent attitude survey shows that a broad majority of upper secondary school students and the majority of teachers experience the benefit of using ICT when performing school work as significant. This figure has increased substantially since the end of the 1990s. The level of ICT use in schools continues to be high.

Sammanfattning av den nationella utvärderingen av ITiS,

Summary of the National Evaluation of ITiS)

IT i Skolan (ITiS) is a major school development initiative in Sweden. In the autumn of 1999, Halmstad University and the School of Education and Communication and Research at Jönköping University were tasked by the Ministry of Education with performing a national evaluation of ITiS. Jönköping University was responsible for performing an in-depth study of 24 school working teams. This task was performed by using participant observations from the field. Halmstad University was responsible for performing a quantitative survey. This survey was performed by using Internet questionnaires directed to a total of 1,500 school working teams.

The qualitative study shows that ITiS brought about rejuvenation to school work, primarily thanks to ICT use in combination with problem-based learning. The summary of the national evaluation was published in 2004.

Riktad kompetensutveckling för specialpedagoger inom ITiS,

Skills development for special education teachers within ITiS

This report from 2004 is an evaluation of a project that pertained to developing the level of competence among special education teachers and teachers within the area of ICT. The project was initiated by the Ministry of Education and Research and the IT i Skolan delegation. It served as a complement to the IT i skolan initiative. The evaluation was performed by researchers and teachers from the Stockholm Institute of Education. The evaluation is based on a questionnaire survey that 618 special education teachers responded to as well as interviews conducted with 20 special education teachers and 10 school leaders.

Seventy-five per cent of the respondents believe that ICT is especially positive for students with functional disabilities and learning difficulties. The most common perception is that students who suffer from reading and writing difficulties and who have trouble concentrating are benefited by ICT. ICT is also experienced as positive in terms of other functional disabilities and difficulties associated with, for example, speech, language and communication problems, visual handicaps, multiple handicaps and motor skill difficulties.

United Kingdom

The impact of ICT in schools, a landscape review

A large number of reports (350) and steering documents were analysed in this report from 2007. The study points out that previous studies used different ways of measuring and evaluating the benefit of ICT in schools and that the definition of effects is unclear in some cases. However, there are several studies that show a direct correlation between using ICT in schools and development of student grades in various subjects. The greatest impact on development of grades can be seen when ICT is integrated into all school subjects and when it is a part of everyday work.

One clearly positive effect found in most of the reviewed studies pertains to student motivation and involvement. The report also indicates that collaboration among students also seems to increase student motivation.

New Technology in Schools

This study is from 2006 and explores the connection between ICT investments and changes in terms of their impact on development of grades in England. The study is primarily based on an analysis of administrative data from 1999-2003 from Local Education Authorities – which is the administration level that is responsible for strategic management of local education administrations. There are a total of 150 Local Education Authorities.

The study also draws some conclusions based on a school questionnaire regarding ICT and its use in English schools. The study finds evidence for a positive correlation between ICT investments and results in primary school. The positive results are most clear in terms of test results in English and when there is a high degree of ICT use in teaching. Another positive effect (even if minor) can be seen in science test results. This study, however, did not show that test results in mathematics were affected.

The Becta Review 2006

This report aims to create an idea of how ICT is provided, its use and the impact it has on schools and learning. The report analyses trends related to how ICT is used and the quick development of the role of technology in British schools. The report is based on current studies that are relevant on a national level.

The report shows measurable positive effects for mark levels, learning, collaboration and motivation. It also shows perceived positive effects in terms of student motivation. The report emphasises a number of challenges with which the education sector is faced, related, for example, to accessibility and quality of ICT use.

ICT in Schools Survey 2004

This report is the result of a questionnaire survey that was performed in 2004. It was responded to by 2,430 English schools. The survey is based on a selection of schools and concerns supply and use of computers in compulsory and special needs schools. ICT is generally perceived as having a positive effect on all subjects for children who have special needs. This perception is most obvious among special needs schools. Seventy per cent of these respondents believe ICT has a significantly positive effect on learning. It is also perceived as having a positive impact on learning for students with problems related to attendance and behaviour.

An investigation of the research evidence relating to ICT pedagogy

This study from 2004 investigates the effect ICT pedagogy has on student attainment. It is based on an analysis of data from 350 published reports and studies plus a small number of case studies involving teachers at schools which implement advanced or integrated use of ICT. The aim of the study was to analyse how ICT is used in schools and how teachers can use ICT to influence attainment.

The study clearly shows that using ICT in schools encourages student attainment can be used. However, the effects depend on how teachers choose and use their ICT resources and how they subsequently use them for other activities both within and outside the classroom. The study also indicates a positive impact on student motivation.

ICT in schools – The impact of government initiatives five years on

This is the third follow-up report from Ofsted related to the British government's ICT initiative in schools. The report from 2004 is primarily based on 548 inspections that were performed between 2002 and 2003 in compulsory and special needs schools. Some case studies were also produced to be used as background data for the report.

The report indicates perceived positive effects within different groups in terms of student mark development, learning, collaboration and motivation. The positive effects of ICT in schools continue to increase, even if ICT is not completely integrated in everyday work and the various core subjects. The report clearly demonstrates that ICT is an important platform and learning medium in various subjects.

Does ICT improve learning and teaching in schools?

One of the main reasons for working towards increased use of ICT in schools is based on a desire to increase learning efficiency and to encourage student attainment. Using these issues as its objectives, this study from 2003 is based on a number of questions:

- Is it possible to show clearly that ICT has positive effects on learning in schools?
- How can ICT be used effectively in schools to encourage student attainment?

Just over 200 studies were analysed in order to provide a broad overview of how education has developed within the area.

The report states that there is evidence that ICT can help students learn and help teachers teach more effectively. The report indicates measurable positive effects on test scores, learning, collaboration and motivation. However, the conclusion is that ICT must be used in a suitable way for the positive effects to be realised.

Using ICT to enhance home-school links

– An evaluation of current practice in England

This evaluation from 2003 concerns present use of what is known as Home School Links in the United Kingdom. Home School Links enables both formal and informal communication between the home and school. It is also a way to increase the level of access homes have to student grades, schedules and other important information. The questionnaire survey was responded to by 115 selected schools. There were also minor case studies at the selected schools.

The report indicates the difficulty of drawing clear conclusions regarding the effects of this project since Home School Links is a relatively new phenomenon in the United Kingdom. However, based on the conducted case studies, the report can assert the existence of perceived positive effects related to ICT in terms of student motivation and that ICT encourages flexible learning in schools and at home.

Impact 2

Impact 2 is one of the most comprehensive studies on ICT and its effects on attainment that has been conducted in the UK. A number of different techniques were used for the evaluation. Some examples are questionnaires, case studies and interviews. The study was published in 2002, and took three years to complete (1999-2002). The aim of the study was to evaluate ICT use linked to student results by using a representative selection of English schools. A total of 2,179 students at 60 schools were studied. Of these, 30 schools were primary schools, 25 were secondary schools and 5 were special needs schools.

One aim of the study was to identify the impact of networking techniques at and outside school, and to investigate if they affect skills acquisition for students between 8 and 16 years of age. Another objective of the study was to create new awareness in terms of whether ICT can and should be used to encourage student development in schools.

This study shows that, in most cases, there is a positive correlation between ICT use in schools and development of grades for subjects such as English, mathematics and science.

Computers for teachers – Evaluation

The aim of this project was to help teachers in England raise the level of grades by offering teachers access to their own personal computer (laptop or stationary). A total of 28,000 teachers were given the opportunity to purchase a computer at half price. The project was implemented and evaluated in two steps.

The first evaluation shows positive effects in terms of teacher confidence and level of knowledge related to ICT use, in addition to positive effects for students.

The second phase of the evaluation was implemented via two different questionnaires (current situation plus follow up) and specifically focused on mathematics teachers for students between the ages of 11 and 14. The evaluation shows that teacher perception of the initiative was that it helped them develop their teaching productivity. Just over half of the teachers also felt like the project increased the level of student attainment at school. The evaluation was conducted between 2001 and 2003.

USA

The impact of Maine's One-to-One Laptop Program on Middle School Teachers and Students

The initial phase of the Maine Learning Technology Initiative (2002–2004) entailed all of the students (27,000) in the state in the 7th class and their teachers (1,700) receiving laptop computers. The schools and teachers received technical support as well as support in terms of integrating laptop computers into their everyday work. This study was performed in 2004. Students and teachers completed questionnaires and the schools were observed.

According to the study, there are clear indications that learning and thus attainment improve when students and teachers receive laptop computers. Between 70 and 80 per cent of the teachers felt like laptop computers had a positive impact on development of grades, learning, collaboration and motivation.

There are also signs that the project increased attendance for some students.

A Meta-Analysis of the Effectiveness of Teaching and Learning With Technology on Students Outcomes

This meta-analysis from 2003 aimed to evaluate the impact information technology has on learning and student development. An important issue in this analysis involved how clear experience-based studies are in terms of the positive correlation between learning that includes technological aspects and student results. A total of 42 studies were analysed, which included approximately 7,000 students.

The analysis indicates that learning that includes technology has a small but positive impact on student results when compared to traditional learning, and the results of the study indicate that the impact technology has on student results is greater than previously believed.

Rest of Europe/OECD

The ICT Impact Report

This report from 2006 analyses conclusions from 17 different impact studies and questionnaire surveys on national and international levels within Europe. These studies clearly show a number of advantages and effects associated with using ICT in schools. The different studies include large-scale impact studies, evaluations of national programmes and initiatives, national inspection reports, etc.

Six of the studies are more quantitative and investigate the direct connection between

ICT use and student results by analysing statistical correlations. Among other things, these show that ICT has a positive effect on students in primary school in terms of learning and grades in English, design and technology.

One of the studied reports, the PISA study, shows a positive correlation between ICT use and grades in mathematics. That investments in ICT make an impact was most clearly perceived when schools used the technology in a focused and efficient manner. A very large proportion of teachers within the OECD believe that ICT has a positive effect on student motivation. Students co-operate to a greater extent when they work with ICT in school.

Are Students Ready for a Technology-Rich World? -What PISA Studies Tell us

This report from 2005 was the result of collaboration between the countries that took part in the PISA study, the PISA Consortium²⁰ and OECD. The report analyses the results from previous PISA studies. The PISA study measures 15-year old students' results as well as how students can use their knowledge and experiences to meet everyday challenges. PISA measures, for example, results in mathematics, reading, science as well as general problem solving abilities. For example, the report shows how students use computers for different types of tasks.

The report shows that there is a strong, positive correlation between access and use of ICT and results. One conclusion from the report is that the minority of students, who have limited access to computers and thus limited experience, perform less positively in school than their peers do in general.

ICT and pedagogy – A review of the research literature

This survey is from 2003, and is based on a review of existing literature and studies within the EU and OECD. It examines the impact ICT-enhanced pedagogy has on student attainment. The study is based on conclusions and analyses from published research reports and a small number of case studies at schools which implement advanced or integrated ICT use. This study is one of two literature studies conducted as part of the British project called ICT and Attainment. Both of the studies were conducted by the same research team, which utilised similar methods and organisation for both studies.

The study shows that when teachers use their knowledge in their main subject and in terms of how students understand content, ICT has a more direct impact on student attainment. The greatest positive effects are attained when the student is encouraged to think independently and is allowed to reflect over his or her own understanding and knowledge.

Student Learning in the Information Landscape

This evaluation from 2005 was performed in order to assess how effective schools are in New Zealand in terms of supporting learning in the new information society. The evaluation was performed on the basis of interviews and visits to 314 state schools on various levels.

According to this evaluation, it is important to introduce knowledge related to information acquisition into education so that students become informed and involved citizens. This knowledge can be viewed upon as a process students must go through to obtain the right skills, attitudes and values that will enable them to navigate and use digital resources such as the Internet effectively. Students also need a positive attitude towards reading in order to function effectively in the information society.

An important aspect related to the development of these attitudes involves the issue of whether schools were able to create a culture that encouraged this development. The assessment shows that in 81 per cent of primary schools, student attitudes towards reading developed in a positive manner as a result of efforts to promote a school environment that encourages learning.

20. The international entity that was responsible for planning and conducting the questionnaire survey

ICT and attainment – a review of the research literature

This is a survey from 2003, which is based on a review of existing literature and studies within the EU and OECD. It examines ICT's impact on student attainment. The study includes data collection from various sources that were published in English, primarily from 1990 and beyond. Some examples are quantitative questionnaire surveys, statistical publications, case studies and metadata analyses.

The literature analysis shows that ICT use in schools has a clear and positive impact on student attainment in most of the national core subjects. The most certain effects are found in English, mathematics and science on all levels of compulsory school. The study also shows a strong correlation between the way ICT is used and student attainment. This indicates that the teacher and his or her attitudes towards ICT are important components.

4. Analysis of demonstrated effects

According to the studies above, ICT contributes to positive effects on student development and on learning a number of skills. This offers schools the opportunity to increase the extent to which they attain their objectives. However, it is ICT use in schools under certain circumstances that has an impact on learning. There are a number of factors in the surroundings that are important in terms of influencing and creating the effects (see Chapter 5).

The analysis in this report is based on the author's interpretation of the reviewed studies as well as of their conclusions that are related to the effects of student development in school. A selection of the studies' conclusions are emphasised in order to clarify which initiatives are beneficial and in what context they are beneficial. The analysis in this report focuses on the conclusions of various reports in terms of demonstrated effects; it does not focus on instances in which effects have not been demonstrated.

Various methods for evaluating impact

There are different methods available for evaluating the impact of various initiatives. However, they all have advantages and disadvantages. One possible method is to perform experiments that use random selection where one group of students uses ICT while another group does not (a control group). The effects on learning are then subsequently measured in the two groups. This method is rarely used in the education sector due to reasons of ethics.

Another method focuses on measuring direct effect through student grades, for example. In this case, mark levels are compared to how often and in what way the technology is used in instruction. This method is used, for example, in conjunction with the English research project called Impact 2. However, the method does not resolve the problem of isolating ICT from other factors that can influence grades.

Finally, there is a third method that entails relevant actors estimating the effect of ICT. In this case, participants are queried about how they personally perceive the effects of ICT. This method allows the impact of ICT to be estimated in light of the complex everyday work in schools. The disadvantage of this method is that respondents may not necessarily have considered the impact of ICT, even if they have used it.²¹

Attitudes towards ICT use in schools

The Swedish study called IT i skolan 2006 – attitydundersökning shows that "a broad majority of upper secondary students and the majority of teachers perceive the benefit of using ICT when performing school work as significant". In general, school leaders recognise the advantages of using ICT in instruction to a greater extent than teachers and students do.

Over 90 per cent of the investigated groups believe that ICT facilitates information search and retrieval for students. Between 70 and 90 per cent believe that the advantages of using ICT in instruction include a natural way to get accustomed to using computers, increased motivation for school work, facilitated learning, stimulated writing process and that it can help simulate various events. All of the groups in this study recognise general advantages to a greater extent than did groups in previous years.

Around 60 per cent of upper secondary students believe that ICT use has helped them improve their ability to express themselves in writing. This figure has remained somewhat

21. Ramböll Management, 2006, E-learning Nordic 2006

constant the past few years. Almost 75 per cent of teachers believe that ICT use has increased opportunities to adapt instruction to the relevant time and space.

Teachers, school leaders and upper secondary students believe that Internet use has helped schools improve their international contacts. Teachers and school leaders agree that ICT in schools can offer support to students with special needs.

Impact on development of grades and learning

There are clear indications that ICT promotes student motivation and learning. There are also a number of studies that clearly show that ICT use in schools is positive in terms of how grades develop.²² The OECD report *Are students Ready for a Technology – Rich World? – What PISA-Studies Tell Us*²³ poses the question of how student use of computers correlates to their performance.

The minority of students who still have limited access to computers performed under the OECD average in the 2003 PISA study. This was particularly apparent for students who did not have access to a computer at home. This effect was found among students with different socio-economic backgrounds in most of the countries. In the 2003 PISA study, students with the least amount of experience of computers in school or at home generally had inferior test results compared to other students. Students who had less than one year of experience using computers were normally only able to solve the simplest of maths problems. Students who had low levels of self-confidence in terms of performing simple tasks on the computer or using the Internet demonstrated inferior results in mathematics (PISA 2003) compared to students who had a great deal of self-confidence.

One issue that becomes clear from this report is that the extent to which students have access to computers and their level of self-confidence when using computers affect their results. The issue of students having access to computers that they can use at home is important in terms of positively developing their results. However, the report also shows that students who use computers the most frequently demonstrate slightly inferior results to students who use them to a more moderate extent. Thus two questions that can be posed are how these high-frequency users utilise their computers and whether they are taking advantage of the technology in the best possible manner.

The Impact 2²⁴ study shows that ICT use promotes greater involvement in the subject, offers scope for reflection and analysis and helps develop skills associated with communication. Interviews with teachers during the study showed that “they were normally convinced of the potential offered by the Internet and ICT in general, but that they were uncertain how they could develop efficient use or how they should integrate ICT into the teaching process”.

The impact ICT had on student motivation was especially clear for students who had previously had difficulties getting involved in their school work; this is an aspect that most of the teachers emphasised.

Studies that utilise classroom observation show that ICT can be integrated into different subjects in many different ways. There were many examples of learning processes being reinforced when ICT was integrated into specific subjects.

A comprehensive review of European studies about the impact ICT has in schools was performed by European Schoolnet.²⁵ The report shows that all of the reviewed studies demonstrated several important overall advantages when ICT was linked to learning. The emphasised advantages include the impact ICT has on student motivation, skills and independence as well as the role it plays in terms of co-operation within groups. Increased levels of student motivation result in increased levels of attention and involvement during lessons, which promotes learning. Individualised learning is also promoted when ICT is used – students work independently at their own pace, based on their own personal needs. Students also take even greater responsibility for their own learning process.

22. Becta ICT Research, 2006, *The Becta Review 2006*; Cox et al, 2004, *An investigation of the research evidence relating to ICT pedagogy*, Becta ICT Research

23. OECD Directorate for Education, 2005, *Are Students Ready for a Technology – Rich World? – What PISA Studies Tell us*

24. Harrison et al, 2002, *Impact2*, Becta

25. Balanskat, Blamire, Kefala, 2006, *The ICT Impact Report*, European Schoolnet

It seems as if ICT can positively impact on both academically strong and weak students. Students with special needs are also benefited by ICT use in school. However, studies show that the technology itself should not be the sole focus in terms of achieving advantages; rather, work must also be focused on using the technology when it is linked to a learning concept. The overall picture clearly indicates that ICT has a positive effect on learning (measurable and perceived effects) and on performance in specific subjects. Six different studies demonstrate that the idea that ICT reinforces attainment in different subjects is statistically proven.

Impact on specific subjects

In the ICT Impact Report, The Becta Review 2006 is emphasised as a study that demonstrates the positive effects of ICT use on attainment in English, science, design and technology. Special techniques, such as interactive whiteboards, have a positive effect on British student performance in mathematics and science, as well as on reading and writing skills acquisition. This effect was especially high for low-achieving students in English and in terms of writing skills acquisition.

Most studies that describe the perceived effect of ICT associated with student performance, indicate a positive view in which teachers are convinced of its impact on mathematics and reading and writing skills acquisition.

A small number of studies (primarily from the United Kingdom) have demonstrated a direct connection between ICT use and attainment. However, there is also some difficulty in demonstrating the direct connection due to the difficulty of drawing general conclusions linked to a certain situation, a certain type of usage or a specific teaching approach. The more embedded or integrated a specific technology is, the greater the impact, which is an important aspect in terms of how ICT in teaching should be approached. Even if a growing number of studies demonstrate the positive impact ICT has on students, potential effects are largely dependent upon how teachers use ICT in their instruction. Studies also show that it is difficult to change teachers' traditional teaching as well as their approach to teaching and learning.

A comprehensive British survey on research and studies in the area²⁶ reviewed a report called ICT and attainment by Cox et al.²⁷ The Cox report demonstrates a clear, positive connection between ICT and attainment in almost all the subjects included in the national curriculum. The most obvious connection was found with English, mathematics and science. A great deal of investment has been made in subject-related digital learning resources in the core subjects in order to promote learning and education.

ICT is also important in terms of language development in general, in particular at the early stages of the learning process as well as when learning to recognise words and build vocabulary in modern foreign languages. Teaching is also of great importance in terms of student attainment when selecting what technology to use or how to use it during lessons. The extent to which the teacher prepares lessons is also significant.

The majority of research shows that available learning resources are relatively limited and that they are often only used by individual teachers, not by entire groups of teachers. The report from Condie et al indicates that it is the scope of ICT use itself that impacts on attainment. The most effective use takes place when ICT is directly linked to curriculum objectives and development of specific skills as well as when ICT is an integrated part of the learning process.

It is not possible to draw any general conclusions from the currently available research in terms of the impact ICT use has on various age groups. Students of various ages can have different levels of access to ICT, and certain types of learning resources may be more or less adapted to different ages or levels of previous knowledge. Some studies measure how often

26. Condie et al, 2007, The impact of ICT in schools a landscape review, Becta Research

27. Cox et al, 2003, ICT and attainment a review of the research literature, Becta

students have access to ICT in relation to which social or ethnic group they belong, but there is no clear evidence to suggest a connection between access to ICT in different social or ethnic groups and student attainment.

The Becta Review 2006 emphasises one study²⁸ related to ICT use in British homes. The study finds that ICT use in education is directly linked to a certain increase of attainment compared to expected levels in mathematics for children who are 6 and 9 years of age. There is also a certain impact on English and mathematics for 11 year olds. At the same time, there is a connection between significantly increased levels of ICT use for the purpose of relaxation and a widespread decrease of attainment in terms of expected results. The conclusion drawn by this report is that it is not access to or general use of ICT that has an impact on attainment; rather, attainment is determined by how the technology is used.

Several studies²⁸ draw the conclusion that ICT has a positive effect on attainment when it is an integrated part of lessons. One of Impact 2's²⁹ conclusions is that ICT use can motivate students and have a positive impact on attainment for students who use ICT to a relatively large extent in their specific subjects. Impact 2 demonstrates a clear statistical connection between ICT use and results on national tests in English (students 7–11 years old), and tests in science³⁰ (14–16 years old) as well as in design and technology (14–16 years old).

There have previously been very few studies available in the financial literature that demonstrate a positive, direct connection between ICT investments and development of grades in British primary schools. The New technology in Schools: Is there a payoff?³¹ report shows a connection related to development in English – a subject which often includes ICT as tool. It also demonstrates a positive connection between ICT investments and science exams. However, there is no direct and measurable impact linked to mathematics.

The New technology in Schools: Is there a payoff? report draws the conclusion that it is increased investments in ICT combined with positive school environments that creates the positive effects found in primary school. The report also draws the conclusion that there is a likely connection between a pronounced increase of ICT investments and development of student grades.

An Indian study³² about ICT in slum areas shows an unexpected and interesting connection between ICT investments and effects on development of grades in mathematics. The study is interesting because it shows a direct and positive connection between instruction that includes ICT support and development of under-privileged children.

A report from Ofsted³³ shows the impact ICT use has in primary schools. Students are very positive to ICT use, they become more involved during lessons, and their learning attitudes and behaviour are positive. Student work developed more quickly in general when they were encouraged to apply their ICT know-how to all aspects of the curriculum.

There are also sure signs that students develop very positively when ICT is used in an effective manner to reinforce reading and writing skills acquisition. This is especially true for students who have previously had behavioural problems or negative attitudes to learning.

The impact of ICT in schools, a landscape review³⁴ says there will be a clear impact on learning and performance when ICT becomes a normal part of classrooms and teaching. The report points to a number of studies that have found evidence that visual technologies (such as animations, simulations and moving images) involve students and reinforce conceptual understanding.

In general, evidence that ICT impacts on attainment is not entirely unambiguous or statistically certain because many of the studies base their conclusions on the effects as they are perceived by teachers and other people. Schools work with a large number of projects and initiatives that aim to increase performance and attainment, which makes distinguishing the impact of a specific initiative from other initiatives difficult.

An evaluation of Scholar – an online program that was created to support students when preparing for national tests in science and mathematics – shows that e-learning has had a

28. Passey et al, 2004, The motivational effect of ICT on pupils, DfES, plus reports from Ofsted and Her Majesty's Inspectorate of Education

29. Harrison et al, 2001, Impact2, Becta

30. General Certificate of Secondary Education

31. Machin et al, 2006, New Technology in Schools, IZA

32. Banerjee et al, 2003, Remedying education: Evidence from Two Randomized Experiments in India

33. Ofsted, 2004, ICT in schools – The impact of government initiatives five years on

34. Condie et al, 2007, The impact of ICT in schools – a landscape review, Becta Research

de facto positive impact on attainment. In geography, ICT reinforced student knowledge in that it increases access to learning resources, improves presentation of reports and written tasks and simplifies communication and experiences that are linked to time and space.³⁵ Similar experiences have been noted in history.

When technology such as information systems is used in the classroom in combination with digital learning resources, learning in subjects such as history and religion can be reinforced. There are also indications that ICT offers many advantages when learning modern foreign languages. Teachers experiment with a number of different resources such as word processors, blogs, authoring tools, video conferencing, interactive videos, multimedia, presentation software, spreadsheets, interactive whiteboards and databases. A great many writing activities performed on computers encourage students to use their new language skills, and to support them with colours, images, audio and video.³⁶ Simulations help students achieve increased levels of understanding for scientific principles and connections. Simulations also enable experiments to be carried out and presented that would otherwise be difficult to perform in a school setting.³⁷

Other studies show that concepts that are difficult to understand can more easily be used in teaching when ICT is used, and that using ICT also enables students to focus on data interpretation and analysis.³⁸ ICT's potential in terms of creativity is clear when used with music. This is an area in which ICT has a positive effect on instruction and learning in general since it reinforces development of different types of musical skills.³⁹

Motivation

According to a survey performed by Becta Research,⁴⁰ there are a large number of studies and reports that have found clear indications that ICT creates effects that impact on student motivation and involvement. The effects of increased motivation are often found in classrooms that focus on learning as a process rather than on resolving a specific task.

Research shows that in mathematics, ICT increases student motivation, increases focus on strategies and interpretation, offers quicker and more precise feedback to students and increases student co-ordination and co-operation. ICT use has also greatly contributed to developing problem solving skills and the ability to perform practical numerical calculations and investigate patterns and connections.

The impact of ICT in schools – a landscape review emphasises the conclusions from a study by Passey et al. The study's conclusions indicate that ICT can promote positive student attitudes to learning and create opportunities for students to recognise solutions to problems. According to Passey, secondary school teachers believe that ICT has a positive effect on student interest in and attitudes to school work. Students also place value on their own work and are more focused on submitting tasks on time.

Using ICT is also effective when students feel that the task fulfils its purpose and when ICT is integrated into the learning process in a manner that reinforces and develops learning so that the effects of the lesson are more long term.

Networking and co-operation

The report called A Meta-Analysis of the effectiveness of teaching⁴¹ says that it is important to demonstrate the effects of ICT on instruction and learning since studies show that use of technology can change teaching approaches – from a teacher-focused or teacher-led model to a more student-focused model in which students work together, are able to make their own choices and can take an active role in their own learning. However, relatively few meta-studies have focused on this area.

35. Condie et al, 2007, The impact of ICT in schools – a landscape review, Becta Research

36. National Centre for Languages/CILT, 2005, Digital video in the MFL classroom

37. Research project InterActive Education, University of Bristol

38. McFarlane and Sakellariou, 2002, The role of ICT in science education, Cambridge Journal of Education

39. Ofsted, 2004, ICT in schools – The impact of government initiatives five years on

40. Condie et al, 2007, The impact of ICT in schools – a landscape review, Becta Research

41. Waxman et al, 2003, A Meta-Analysis of the Effectiveness of Teaching and Learning With Technology on Student Outcomes, Learning Point Associates

A report from Waxman et al shows that the effects of ICT on student attainment are about twice as large as previous analyses of this kind have shown. This indicates that the overall impact of technology on student development is greater than previously thought.

The Swedish evaluation of ITiS shows that problem-based learning offers students greater freedom. Teachers expect students to take responsibility for planning, performing and presenting their work appropriately, and students refer to one another to a large extent since they often work in groups. Many teachers were surprised by the level of responsibility and involvement demonstrated by students during the ITiS project. Teachers say that students support each other well and use each other as resources, not least of all in terms of computer skills. Teachers also say that the different types of skills and qualities possessed by students are more clearly expressed when flexible education and different sources of information and teaching tools are used.

However, teachers believe that students need more help in their work related to ICT than they previously believed. Teachers also say that it is more difficult to check student work when they spread out while working. Teachers also believe that they have a tendency to steer students too much, and that they need to adapt instruction to the varying degrees of motivation and competence of students.

Children with special needs

A Swedish evaluation⁴² on special education teacher skills development sees a clear, perceived benefit of using ICT with students who have special needs. The evaluation is from the Stockholm Institute of Education. Many of the skills development participants expressed frustration in terms of “being aware that ICT can entail a great deal of benefit for students, but personally not possessing the knowledge and/or time needed to develop use”. Seventy-five per cent of the participants believe that ICT is especially positive for students with certain functional and learning disabilities.

Primary school teachers say that it is easier to use the students’ own experiences and thoughts as the starting point when using technical aids in the classroom, and that technical aids such as ICT can help lower achieving students use more of their own material. Teachers of older students often feel like they fill a supervisory role. They say that their students are able to work more independently and can, for example, correct their own work by using ICT. According to most teachers, ICT can simplify writing, doing homework and, to a certain extent, serve as a source of information via the Internet.

Teachers also say that using computers can in many cases help them individualise instruction when they use exercise programs that can be adapted to student level.

The results also clarify that teachers need and are interested in increasing their level of knowledge in terms of how ICT can be used as a compensatory tool or teaching aid. Educational background and how accustomed teachers are to using ICT varies, which is why training must be tailored to teacher need. The unique aspects offered by ICT must also be focused upon more clearly. Otherwise, there is a risk that ICT will simply be used with old pedagogical methods instead of new working methods being developed. The potential for change that exists in terms of using ICT with children who have special needs must also be discussed from an organisational perspective.

According to the ICT in Schools Survey 2004,⁴³ ICT is generally perceived as having positive effects in terms of helping students with special needs follow the British National Curriculum. The special needs schools queried in this survey have a more positive attitude towards the effect ICT has on its students than do compulsory schools. The schools that have come a bit further in their use, maturity and self-confidence related to ICT, and that were assessed to be more “e-mature”⁴⁴, more frequently perceived ICT as having a positive effect on students with special needs.

42. Brodin et al, 2004, *Lyrisk, arg och frustrerad Riktad kompetensutveckling för specialpedagoger inom ITiS*, Stockholm Institute of Education

43. Prior & Hall, 2004, *ICT in Schools Survey 2004*, Becta

44. The expression e-confidence is used to describe the level of digital or e-maturity or e-self confidence

Utilisation of ICT to reintegrate students with attendance or behavioural problems can also be related to degree of e-maturity. The schools with the least amount of e-maturity were also those least likely to use ICT for reintegration. The schools that had the highest levels of e-maturity were those most likely to use ICT for reintegration. This measurement was performed as a means to gauge the perceived level of the school's ICT strategy, Internet access, staff know-how and self-confidence as well as the school's ICT use in mathematics, English and science.

Ofsted (2004a) shows that e-mail use affects development of grades positively for students in primary school who were previously unwilling to learn new things. A study from RNID⁴⁵ (2004) on deaf students, demonstrates that development of grades and student motivation is positively affected when ICT is used effectively.

Ofsted's review⁴⁶ of ICT use in combination with physical exercise (in secondary school) demonstrates a positive connection between ICT and attainment for students between the ages of 14 and 16; digital video use improved student movements and their ability to observe and analyse various movements. Other aspects that were improved include motivation to learn and more consistent and precise performance.

There are also studies that show how ICT is used with children with special needs, as well as how ICT can improve attitudes, concentration and motivation in terms of learning. For example, projects such as Notschool⁴⁷ use mobile technology to help students learn who are on the verge of quitting school, lack confidence in adults, are unmotivated or who experience other difficulties related to learning. Notschool is a nation-wide, Internet-based network that offers an alternative to traditional education for young people who are no longer able to cope with school work for one reason or another.

There are a number of studies available regarding how computerised attendance rolls improve student attendance. In one study,⁴⁸ 60 per cent of primary school teachers and 80 per cent of secondary school teachers say that attendance increased after attendance rolls were introduced. Other studies⁴⁹ point out certain difficulties related to analysis and follow-up of high levels of absence, at the same time that teachers see positive results such as improved and more frequent dialogue between the home and school.

45. Royal National Institute for the Deaf, London

46. Ofsted, 2004, ICT in schools The impact of government initiatives five years on

47. Notschool began as a research project in the UK and is now run as a foundation Inclusion trust

48. National Audit Office, 2005, Improving School Attendance in England

49. Band et al, 2005, Evaluation of Capital Modernisation Funding for Electronic Registration in Selected Secondary Schools: 2nd interim report, University of Warwick

5. Ambient and influencing factors

There are a number of ambient and influencing factors that are important in terms of creating these effects. Some of the more central factors that impact on students' development are described below.

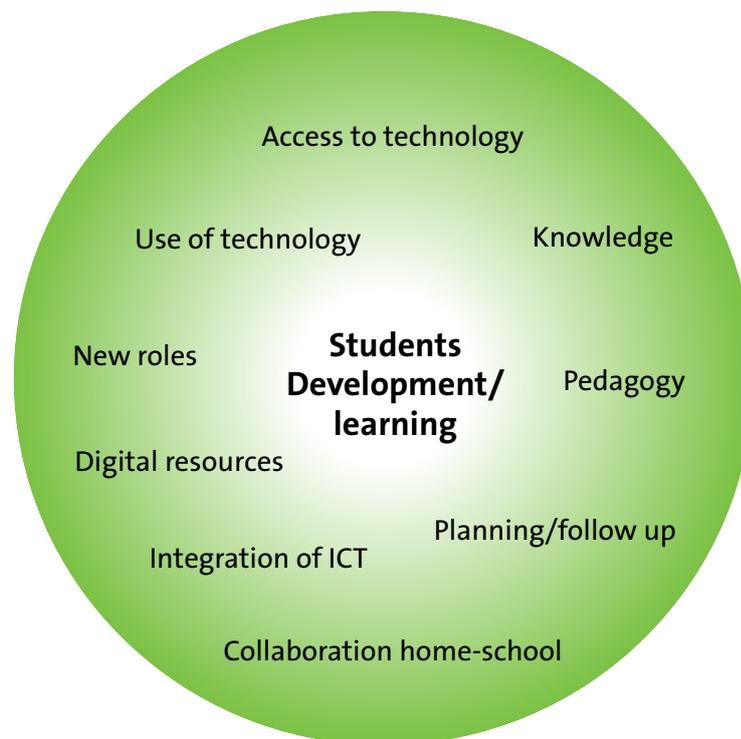


Figure 2. Ambient and influencing factors to students development and learning.

Above figure shows a simplified image of the model that is used in this analyse, an image of a number of ambient and influencing factors to students development and learning in different ways.

Utilisation of technology

According to the IT i skolan 2006 – attitydundersökning study, an increasing number of Swedish teachers have used ICT in their teaching since 2004. Just over 40 per cent of the teachers who have access to the Internet at school use it to a great extent in their teaching. Upper secondary teachers use the Internet to a greater extent than do compulsory level

teachers. Teachers who have taken part in the ITiS project are more inclined to use the Internet in their teaching than other teachers are.

The proportion of teachers who believe that using computers as a teaching tool benefits them greatly has increased over the past few years; the proportion has now reached 60 per cent. Upper secondary level teachers recognise benefit to a greater extent than do compulsory level teachers, and young teachers believe that using computers as teaching tools is greatly beneficial to a greater extent than their older colleagues do. Upper secondary level students, teachers and school leaders all have a positive attitude towards using the Internet in teaching; however, school leaders are more positive than teachers and upper secondary level students.

The IT i skolan 2006 – attitydundersökning study shows that teachers see obstacles to using the Internet in instruction to a greater extent than do students and school leaders. The obstacles that teachers name as being most significant are insufficient funds, too few computers, insufficient level of competence on the part of teachers and inferior equipment. Upper secondary level students recognise obstacles such as incorrect or false information on the Internet, slow computers and that some students misuse the Internet or are not interested.

About half of the teachers and school leaders believe that the Internet has increased student awareness of the importance of source criticism. Upper secondary students believe that the general level of awareness has increased to a greater extent, and even more believe that their own awareness in terms of source criticism has increased. Around ten per cent within all the groups, however, believe that awareness of source criticism has decreased.

A majority of upper secondary students and school leaders believe that ICT use has helped students improve their ability to express themselves in writing. Teachers agree with this belief, but to a slightly lower degree.

Access to computers

The E-learning Nordic 2006 study shows that students, teachers and parents feel that ICT has a positive effect in terms of improving learning. The study indicates that there is a connection between availability of computers with an Internet connection and learning effects. The headmasters in schools that have the lowest number of students per computer (less than four students per computer) have observed that ICT has greatly simplified integration of new teaching methods into instruction. The majority of teachers in these schools have attended ICT skills development training, and the headmasters have followed up on how the skills are used.

The headmasters at the schools included in the study also say that they place a great deal of emphasis on ICT issues in development discussions with staff and that they regularly ask teachers how they use ICT in their teaching.

The Computers for teachers⁵⁰ programme was a national British initiative that focused on helping teachers promote development of grades by offering them access to their own computers. Many of the participating teachers believe that the programme had a positive effect on students. Because teachers felt more secure when using ICT during lessons, they dared experiment more, which increased the chance of ICT being effectively integrated into lessons. This also affects students positively since they are given a greater opportunity to investigate ICT in the classroom, which also impacts on student motivation, learning and behaviour.

Teachers believe that increased use of ICT is especially useful for children who suffer from learning disabilities since ICT use allows teachers to prepare suitable tasks for individual needs and each individual more effectively. However, teachers believe that allowing certain students to use computers distracts them from focusing on the task at hand.

50. Becta, 2001, Computers for teachers evaluation

Maine's One-to-One Laptop Program is an initiative in Maine in the U.S. All of the students in the state in the seventh and eighth class and their teachers received laptop computers. The schools and teachers received technical support as well as support in terms of integrating laptop computers into their everyday work. The first phase of the evaluation⁵¹ shows that teachers most frequently use the computers to develop instructions and material, search for material for lessons and to communicate with colleagues.

Just over 70 per cent of teachers believe "that using the computers helped them work more effectively in terms of reaching educational objectives and individualising curricula to suit specific student needs".

This study indicates that the level of teacher know-how related to ICT use and its effect on instruction will increase as teachers become more experienced in using computers over time.

Seventy-five per cent of students believe that the laptops helped them become more organised, and that they could more easily work through and improve their responses to tasks. Almost 70 percent of students believed that they worked more effectively with the laptops and that they were more involved with school and their co-operation with classmates. Two-thirds of all students say they gained a better understanding for what they needed to learn; that is, they better understood what the teacher wanted them to learn.

Just over 80 per cent of all teachers believe that all types of students become more involved in their own and other people's learning and that their work maintains a higher level of quality. Of special interest to teachers was how students with behavioural or attitude problems developed. These students were reported to have improved their attendance and behaviour, increased their levels of motivation and involvement as well as become more active in the classroom. This development is an important prerequisite for learning, and it creates entirely new opportunities for these students to develop.

Children with special needs also developed very positively in terms of motivation, involvement and participation.

One important aspect of the project involved the development of technologically knowledgeable students who could support (iTeam) teachers and students in the classroom in the event of technical problems. A preliminary analysis of successful schools shows that one important factor involved one or more key individuals at the schools functioning as an ambassador and formal or informal leader for the programme. Another factor that may have influenced the success of these schools is that students were allowed to use their computers at home.

Utilisation of laptop computers in the classroom by students and teachers has been the focus of several studies and evaluations in terms of the effects of use on learning. Conclusions from the studies show that use of and access to laptop computers increase the level of motivation and involve students to a greater extent, especially when they are used with interactive whiteboards.⁵² Mobile technology offers additional options in terms of learning, and learning tools can be adapted to individual learning styles and preferences. There are a number of clear indications that mobile technology involves students. A current project focuses on the development of creative strategies for how teachers should use the technology to achieve different educational objectives.⁵³

Using interactive whiteboards

Learning is reinforced when computers, word processors and/or presentation software is combined with other technology. According to The impact of ICT in schools – a landscape review,⁵⁴ this is particularly clear when interactive whiteboards are used.

Utilisation of interactive whiteboards has been examined and evaluated more than any other type of presentation technology. The general conclusion drawn from qualitative studies is that interactive whiteboards function very well as a tool for the entire class, in addition

51. Silvernail, 2004, The impact of Maine's One-to-One Laptop Program on Middle School Teachers and Students, University of Southern Maine

52. Cunningham et al, 2004, Laptops for Teachers: An Evaluation of the First year of the Initiative, National Foundation for Educational Research

53. Condie et al, 2007, The impact of ICT in schools – a landscape review, Becta Research

54. Condie et al, 2007, The impact of ICT in schools – a landscape review, Becta Research

to there being several educational advantages associated with using the technology.

One of the studies that was reviewed⁵⁵ in *The impact of ICT in schools – a landscape review* draws the conclusion that introducing interactive whiteboards had a clearly positive effect on classroom interaction in primary school classrooms in the United Kingdom; however, the results are not as clear in terms of whether interactive whiteboards offer positive long-term effects on reading, writing, mathematics and science attainment.

The *Embedding ICT in the Literacy and Numeracy Strategies* study draws the conclusion that interactive whiteboards can help teachers improve the quality of their presentations, increase student activity through interaction with the technology and each other, increase student motivation and improve student communication (speaking and listening) abilities. Some of the other conclusions from the study are that interactive whiteboards make education more relevant and up-to-date in that concepts are introduced in a new way. Interactive whiteboards can also encourage group work and connections to be made between different subjects: the technology increases effectiveness in terms of passing on knowledge and experiences among students.

An investigation of the research evidence relating to ICT pedagogy report shows that access to ICT resources affects ICT use in different subjects.⁵⁶ A small number of available computers in the classroom, and thus limited student access to computers, is shown to have a limiting effect in some cases. Lessons in which the entire class uses interactive whiteboards, on the other hand, show both positive and negative effects. Interactive whiteboards encourage student discussion and help them visualise difficult concepts and processes. However, some teachers only focus on the presentation and not on the use of simulations or modelling, which might otherwise challenge students and help them develop to a greater extent.

Utilisation of interactive whiteboards in groups or with the entire class allows the teacher to obtain more student feedback when listening to their explanations.⁵⁷ Teachers report that students who had barely spoken during lessons previously became more motivated to discuss their work with other students, which helped the teacher better understand how they acquired their knowledge.

Another study⁵⁸ related to ICT in primary schools shows that students perceive use of interactive whiteboards as a means to help them think about their own learning in a more in-depth manner; that is, there is a metacognitive effect. Students also believe that interactive whiteboards help teachers explain concepts more effectively. Students with difficulties related to reading and mathematics thus also feel more motivated when interactive whiteboards are used.⁵⁹

Interactive whiteboards have also helped autistic students work together during lessons in reading and writing proficiency. Digital photographs are used in combination with interactive whiteboards to stimulate an increased level of participation.

Analyses of the literature related to effective use of digital videos (and editing) show clear indications that use increases motivation to a large degree, increases reading and writing skills acquisition, is flexible in terms of different learning styles and encourages collaboration and more in-depth conceptual understanding in several subject areas. Effective use can be defined as ICT being integrated into different activities in the learning process and as being used to support attainment in a manner that would not have been possible without the technology.

Access to knowledge and competence development

The results of the E-learning Nordic 2006 study and other studies show that poor results can be improved for entire schools through more strategic and systematic use of ICT on several levels. For example:

55. Higgins et al, 2005, *Embedding ICT in the Literacy and Numeracy Strategies*, University of Newcastle

56. Cox et al, 2004, *An investigation of the research evidence relating to ICT pedagogy*, Becta ICT Research

57. Cox et al, 2004, *An investigation of the research evidence relating to ICT pedagogy*, Becta ICT Research

58. Wall et al, 2005, *The Visual helps me understand the complicated things*

59. Ofsted, 2004, *ICT in schools The impact of government initiatives five years on*

- mandatory ICT use in all subjects
- ICT use follow-up on individual school level
- increased focus on ICT use in teacher training programmes

The study also shows that even if two out of three teachers have participated in ICT skills development at some point over the past three years, only about one out of three teachers feels they have a sufficient level of competence to incorporate ICT into their instruction. Their lack of skills thus affects their ability and willingness to use ICT in their instruction.

The extent to which teachers recognise the relevance of using ICT affects the extent to which they use it. Only about 40 per cent of teachers believe using ICT to support the theoretical content in their teaching is very relevant. About 30 per cent of teachers believe that ICT can be used to a large degree to improve or develop their pedagogical and didactic methods.

It is reasonable to believe that teachers have developed the basic skills necessary to integrate ICT into their teaching since most of them have computers and an Internet connection at home in addition to having taken part in some type of skills development. E-learning Nordic 2006, however, indicates that skills development has not provided teachers with more than basic skills and that there may be a link missing between the basic level of skills that teachers have and teaching methods. Students in many schools believe that they have very good ICT know-how while teachers have a different opinion regarding the level of knowledge possessed by students in the area. As a result, there are different opinions regarding what ICT competence or “digital competence” comprises. The differences of opinion can be seen as the result of a generation gap.

The report emphasises that a common understanding and definition of digital competence is necessary if both teachers and students are to understand what to aim for in terms of ITICT use in instruction.

E-learning Nordic 2006 says that “there is a very large gap between how ICT is used at school and outside school and that students feel like they primarily learn about ICT outside school. This gap can also be seen as generational. Students have acquired skills outside school that are not recognised within the educational system.”

The national evaluation of the Swedish initiative ITiS concludes that “as a result of ICT being introduced as a pedagogically thought-provoking aid during teacher skills development and development work, that the initiative has encouraged reflection, thought and trying out new working methods.” New concrete experiences form an important basis in terms of changing the way teachers and students look upon teaching and working methods. The evaluation emphasises that the extent to which ICT helps teachers recognise the varying levels of student skill related to the new technology is an interesting aspect. This is particularly true in terms of the extent to which ICT as a teaching tool can be useful for groups of students who especially need to have their needs met.

The evaluation also shows, that in a broad sense, the factor that has the greatest impact on student knowledge and skills development is the level of competence possessed by teachers. This is also true when ICT is used as a teaching tool in instruction.

It is important to create opportunities in which practical experience and knowledge related to effective methods can be shared, as well as to support schools and school leaders in their efforts to develop use of technology in order to meet educational objectives. Internal transfer of knowledge in the area of ICT in schools is an important tool in terms of increasing the level of competence among teachers and school leaders.

Pedagogical development

A British study that was performed as early as 1999⁶⁰ indicates that general use of computers does not offer any major impact on student performance. This study concluded that

60. Mosely et al, 1999, Teacher Training Agency Study

effective teachers and schools tend to use an innovative approach or use resources that they believe are effective in terms of learning. The important issue in terms of student development involves how ICT is used.

The same study observes that ICT impacted on learning in all of the (16) reviewed development projects. However, the conclusion is that ICT does not automatically impact on learning in a positive manner; the teacher must be able to raise the level of student grades when ICT is used to support reading and writing skills and numerical thinking. Another conclusion from the study is that ICT can have a positive effect when it is utilised for specific elements of learning, and when it is based on knowledge and logic from relevant research on ICT, pedagogy and development.

The E-learning Nordic 2006⁶¹ study observed that ICT has a positive impact on basic skills such as reading, writing and arithmetic, primarily in years 5 and 8. This effect is apparent among both theoretically weak and strong students, and teachers say that ICT use does not increase the differences between the groups. The study also indicates that ICT helps improve student skills the more it is used, the more types of ICT are used and the more varied the utilised teaching methods are.

ITICT also allows teachers to individualise their teaching since students can work at their own pace according to their preferred study technique. They can also work with different subjects. At the same time, teachers can provide each student with personal support and feedback. However, according to E-learning Nordic 2006, this opportunity could be better taken advantage of: one of the study's conclusions is that "the effects of ICT use on individual student performance could be intensified, but to do so, the methods that work the best must be thoroughly documented".

The Does ICT improve learning and teaching in schools? study shows clear indications that ICT can help students learn and teachers teach more effectively.⁶² It is not the case, however, that ICT makes a difference simply because the technology itself is used; rather, research shows that there are a number of issues that must be considered for ICT to have a positive effect. According to this study, ICT has a minor impact compared to other initiatives in schools that have been studied. However, it is possible that the effects of ICT use are increasing, even if they are still relatively minor.

Other types of initiatives such as students tutoring students and homework result in a larger average impact for all students. A longitudinal study in the U.S. (Weaver 2000) on computer use that was performed in the late 1990s shows a correlation between ICT use when it is part of the curriculum and development of student test results.

The New Technology in Schools⁶³ report describes two main areas of ICT use in schools – education in using computers and software, and learning that is supported by computers and new technology. Basic knowledge related to using computers is normally considered very useful while learning that is supported by computers is more controversial. Some researchers say⁶⁴ that having computers in the classroom can be distracting in some situations, and that they replace more efficient learning techniques.

Developing teacher and student roles

The ICT Impact Report clearly shows that ICT has an impact on learning, but not all of its effects are positive. Even though teachers perceive a high impact on instruction and learning, the perceived effect on teaching methodology is much lower. The greatest development over the past few years is related to improved teacher attitudes towards ICT. Increased ICT use and integration in learning has resulted in many teachers coming to the conclusion that ICT has a pedagogical value.

There are also clear indications that teaching roles are changing – either forced by technology or as the result of actively focused efforts on the part of teachers. One of the conclusions drawn in The ICT Impact Report is that "the most difficult aspect in terms of changing the

61. Ramböll Management, 2006, E-learning Nordic 2006

62. Higgins, 2003, Does ICT improve learning and teaching in schools?, Newcastle University

63. Machin et al, 2006, New Technology in Schools, IZA

64. Angrist & Lavy, 2002, New Evidence on Classroom Computers and Pupil Learning

teacher-student relationship is for the teacher to relinquish control and to have faith in students being able to plan their own work independently”.

The literature shows the importance of ICT use being linked to a pedagogical approach in order for learning to be developed. According to The ICT Impact Report, however, there are a great many indications that the majority of teachers have not yet embraced the new teaching methods. This is partially the result of teachers not believing they have a sufficient level of competence that allows them to benefit from ICT when using it to support new teaching methods.

The Using ICT to enhance home-school links report refers to a study⁶⁵ by Facer et al on how ICT impacts on teaching in schools. The study indicates that the educational system shows tendencies to see students as consumers rather than as producers of information. This means that the focus of education is to collect and sort information rather than concentrating on critical analysis and interpreting information. The report observes that an alternative teaching approach that is more focused on communication, production, problem solving and co-operation is needed.

The Swedish ITiS programme evaluation emphasises that the aim of the initiative was to involve students early in the work process. Many students feel like they were more involved and committed to projects linked to ITiS than they were to their other school work. Computers are experienced as fascinating and as being able to increase the level of some students’ motivation. Many students also feel like they learn a lot from working with different medias as well as independently. Students feel like they take more responsibility, work more independently and influence implementation to a greater degree. Since work is primarily carried out by students working in groups, they also feel like the teacher’s attention is split between being a more “traditional” teacher and a tutor, which is an aspect they experience as negative.

The climate of development is more dynamic and positive at some schools than at others. Schools where the evaluation found a positive climate of development have teachers who work in an environment which is characterised by “creative ideas emerging, reigning curiosity and teachers who are not afraid of change”.

The results of the evaluation offer evidence that the ITiS initiative would never have achieved the results it did had there not been a peer adviser at each of the schools. The peer adviser’s contribution was primarily to support working teams by functioning as a sounding board for reflection and exchange of ideas, rather than to function as an expert.

In response to the question of whether ITiS encouraged new ways of thinking, the questionnaire survey in particular shows that the projects that were linked to ITiS functioned as a thought-provoking process for working teams, which increased their level of reflection and meta-learning. That is, individuals learned more about how they learn and also became more aware of ICT as a teaching tool. The quantitative study shows that teachers say, to a fairly large degree, that they reflect upon how they learn themselves; this applies to compulsory school teachers to a greater extent than to upper secondary school teachers.

In general, however, teachers reject the idea that ICT know-how on the part of students can provide additional know-how to instruction. The evaluation indicates that teacher scepticism to ICT know-how on the part of students may be based in a fear teachers have of their relationship with students changing into a situation for which they are not prepared; that is, a relationship with students that is on more equal footing.

The fact that each participating teacher received a computer for personal use helped them to plan and carry out their work in a practical pedagogical manner.

65. Facer et al, 2001, Construction the Child Computer User

Using learning resources

The British ICT and pedagogy study on ICT and pedagogy⁶⁶ shows that teacher pedagogy and pedagogical ideas influence how teachers use ICT, which impacts on student attainment. The manner in which ICT is used during lessons is also influenced by the teacher's level of expertise in the subject as well as how ICT relates to it.

Some teachers choose ICT resources that correlate to a specific subject, while others use ICT to present student work in an innovative manner, without there being any direct link to the subject.

According to some studies, the impact is the greatest when students are encouraged to think on their own and to call their own understanding into question – individually or in groups, with software that is focused on the subject.

The teacher's personal attitudes towards teaching, however, also play an important role in terms of creating learning opportunities that are communicated via technology. According to a study by Cox et al, teachers need extensive knowledge of ICT in order to choose appropriate learning resources. They also need to understand how to integrate ICT into lessons and perhaps also how to develop new methods in order to achieve an increased level of integration. Studies show that the most effective way to use ICT is when the teacher (and software) can challenge student understanding and thinking – either through common classroom discussions and interactive whiteboards or through individual or pair work on a computer. The study also seems to show that if the teacher has the ability to organise and stimulate ICT-based activities, that full class discussions and individual projects are equally as effective.

One important effect of ICT use in various subjects is the degree of teacher access to and extent of ICT resources. The impact of ICT in schools is affected when there are a limited number of computers in the class, in particular for primary school. Less access to computers means less use per student, and, thus, a smaller impact on learning. New methods are required when using ICT, and in some instances teachers need to develop their role as sound-board and “enabler”.

Teachers must also take on a leadership role in terms of planning, preparing and following up lessons. Research shows that an increased level of lesson planning helps students become more focused, which results in an improved learning effect.

ICT has different areas of use, and it is used in different ways in the classroom according to a study performed by Becta.⁶⁷ The level of the teacher's expertise in his or her subject area as well as how ICT is integrated with the subject impact on use and the effects of use. There is a great difference between teachers who select learning resources that suit a specific subject and teachers who choose to present student work in an innovative manner without there being a direct link to the subject.

An investigation of the research evidence relating to ICT pedagogy shows that ICT use has a more direct impact on student attainment when teachers use their knowledge, both in terms of their subject and their pedagogical understanding of how learning takes place within their subject. Pedagogical know-how and values are important in terms of creating learning situations in which knowledge can be communicated by using ICT. The technology can be used as a subordinate tool that merely reinforces existing teaching approaches or as a strategic tool that is used to change the way teachers and students relate to one another.

Teacher awareness of the potential offered by ICT and available learning resources is important in terms of developing ICT use in schools. There are a great many positive examples of teachers who are very knowledgeable about specific resources within a specific area, but it is more unusual that teachers have comprehensive knowledge of the broad range of available resources. This means that students are unable to take full advantage of the learning opportunities offered by ICT.

66. Cox et al, 2003, ICT and pedagogy – a review of the research literature, Becta

67. Cox et al, 2004, An investigation of the research evidence relating to ICT pedagogy, Becta ICT Research

Planning and follow-up

Teachers must understand that technology-assisted learning entails a new approach to pedagogy, planning, preparation and how curricula are perceived by students.⁶⁸ The impact of ICT in schools – a landscape review draws the conclusion that many schools have developed an ICT strategy, but that the strategy is in many cases several years old, does not correspond to the school's other strategies and that students and teachers are not generally aware of its existence. The report indicates that ICT needs to be incorporated into the overall strategies of schools and be used to reach their objectives.

An investigation of the research evidence relating to ICT pedagogy⁷⁰ study indicates that a greater proportion of headmasters perceive ICT has having secured integration of new teaching methods into instruction at schools that have experienced ICT users among its teaching staff who help others utilise ICT. The study emphasises that not only today, but also in the future, that a large proportion of lessons will be interactive. Thus, in order for ICT to have an increased impact on learning, teachers must understand that interactivity requires new approaches in terms of pedagogy and lesson planning.

Some teachers are already radically changing they way they teach, but the majority of teachers are using ICT to add to or reinforce existing working methods. Teachers need to develop and initiate proactive strategies to support, guide and promote suitable activities linked to learning.

A large proportion of pedagogy consists of planning, preparation and follow-up. Many teachers report that ICT use changes their role from that of traditional leader to a process supervisor and sounding board – even though they still primarily have a leadership role in the learning process since they are responsible for planning and overseeing the course of learning. There are studies that show that an insufficient amount of planning results in less focused student work in classrooms and less positive effects. Thus, teachers and teacher trainers need to change their approach regarding how ICT should be integrated into the entire pedagogical process.

When ICT does not successfully create added value for teaching and learning in different subjects, the reason is often related to planning being determined by the technology – not the specific subject.⁶⁹ The teacher must understand why students should use a specific application in a specific context if results are to be positive as well as possible to develop. There are examples of where ICT use is less productive, for example when digital learning resources on the Internet are used without there being a specific purpose or where paper-based information would be more useful and flexible.

ICT integration

One study observes that a critical factor in terms of effective ICT use is that it must be linked to the pedagogical work at the school. Such a strategy should take future, long-term development into consideration and include methods for measuring and following up development in relation to identified milestones and objectives. Innovation and development often begin within a specific age group or subject area, but the entire school must be involved in order for the technology to be integrated into the everyday work of each student.⁷⁰

A large majority of parents and students are very clear in their response to E-learning Nordic 2006 in terms of the importance of schools and teachers actively incorporating ICT into instruction and teaching methods. ICT should also be incorporated into the everyday workings of schools generally, including co-operation between the home and school. One of three teachers feels like their knowledge is too limited in terms of being able to use ICT more in their teaching or when planning tasks and exercises.

68. Condie et al, 2007, The impact of ICT in schools – a landscape review, Becta Research

69. Ofsted, 2004, ICT in schools – The impact of government initiatives five years on

70. Condie et al, 2007, The impact of ICT in schools – a landscape review, Becta Research

According to E-learning Nordic 2006, ICT can offer immediate and reliable benefits in terms of co-operation between the home and school for everyone involved – parents, students, teachers, school leaders and municipal educational authorities. However, many schools and municipalities seem to be unaware of the opportunities offered by ICT. According to the study, headmasters and local school authorities need practical guidelines for using ICT in order to improve the dialogue between the home and school.

One of the study's conclusions is that school headmasters and leaders need to become more professional in terms of incorporating ICT into the organisation if the potential effects of ICT are to be realised. Significant investments have been made in ICT, both on local and regional levels; however, there has been a lack of clear criteria for measuring success and following up structured results. This study also observes that the situation at many schools can be compared to purchasing ten laptop computers without unpacking them.

Collaboration between the home and school

The Using ICT to enhance home-school links⁷¹ report says that it can be difficult to draw conclusions regarding ICT's impact in terms of changing learning or how communication with parents is improved. However, the study shows preliminary indications that there are a number of benefits related to learning and in terms of using ICT to create links between the home and school. The report shows, for example, that students can refine and expand their school work when ICT is used in a flexible manner to extend learning to outside the confines of school.

In several of the schools that were studied, teachers received laptop computers that they were allowed to use both at school and at home; this pronouncedly increased their ICT use when planning, communicating and presenting. Students were also given access to laptop computers in some cases, and developed a substantially increased level of understanding and ability in terms of using ICT resources in a suitable manner. This increased level of understanding also pertains to students who have access to traditional home computers and who frequently use computers at school.

The report draws the conclusion that increased communication between the home and school is especially important for students who have a hard time taking part in school work on a regular basis due, for example, to them being cared for at home or at hospital for an extended period of time. Video conferencing and other types of online communication offer these students continuity in their learning which would otherwise not be possible.

The report also indicates a number of administrative advantages related to developing co-operation between the home and school. Teachers and parents were close to gaining access to various types information via the Internet in several of the studied cases, which will impact on administrative work. For example, using e-mail when communicating means that parents and students have better access to teachers and that teachers have better access to one another. There are also clear indications in the case studies that ICT-based administrative systems can reduce teacher workload at the same time that they increase openness in communication with students and parents. Electronic attendance rolls, software that supports report writing about students and access to information related to learning via the school's intranet are of particular value.

Strong leadership and good administrative skills are important elements in terms of developing effects that impact on the efforts of the entire school. The most successful schools are those that are able to test different solutions at the same time that they share a clear and common vision for developing education. The schools that support their teachers on site are the schools that are most successful in terms of developing and achieving their ICT objectives.

The study also shows that development towards increased co-operation between the home and school increases the necessity of teachers developing ICT skills. At the same time, it shows that ICT skills among teachers increase more quickly when use is integrated with the school's policy and practical workings.

71. Becta, 2003, Using ICT to enhance home-school links An evaluation of current practice in England

The Student learning in the Information Landscape⁷² report presents an evaluation of how effective schools in New Zealand are in terms of supporting learning in the new information society. The large increase to the amount of information to which students have access via the Internet means that it is more important than ever that they learn to evaluate the information they obtain from various sources. It is a matter of teaching students to become information literate and for them to learn the skills, attitudes and values needed to navigate and utilise digital information successfully. Students also need to develop a positive attitude towards reading in order to utilise different types of information on the Internet or from other sources effectively. It is the school's task to provide interesting opportunities for learning that enable students to examine and use information with confidence and the appropriate skills.

The report indicates that primary schools effectively support students in terms of developing positive attitudes to reading, which is apparent in student results within the area. Eighty-one per cent of primary schools were effective in this area, and half of the schools were very effective. Many schools have increased quality in classrooms as well as increased the amount of learning resources in order to support these efforts. However, methods to evaluate student results and development in terms of digital competence are also necessary.

72. The Education Review Office, 2005, Student Learning in the Information Landscape

6. Strategic proposals for improved learning in school

The analysis of current research shows that ICT has a positive impact on student development and learning, which means that schools have a greater opportunity to achieve their objectives. However, there is no mechanical relationship between using ICT and its impact on learning; rather, it is ICT use in schools under certain circumstances that has a positive effect on development and learning.

There are a number of factors in the surroundings that are important in terms of creating these effects, and based on the conclusions of the reviewed studies in this report, it is possible to formulate a number of strategic proposals that are linked to long-term efforts to create a school of the future – a school in which ICT is perceived as synonymous with pedagogical development and creative learning. The proposals can probably be applied to most European countries. However, decision-makers must select the elements that are relevant to the given context and level of development of each individual country.

The proposals are the author's recommendations regarding which initiatives should be considered as the most central in terms of ICT use having clear and positive effects on instruction and learning.

The strategic proposals for improved learning in school include:

- a national plan for how technology should be used in schools
- increased level of ICT access and integration
- a model for measuring and encouraging e-maturity and digital competence
- increased focus on use of digital learning resources and new working methods

A national plan for how technology should be used in schools

There must be a national plan and strategy for using ICT in teaching. The national plan and strategy can contain all or some of the proposals above. The idea is for decision-makers to select the components that are most relevant to the organisation's or educational system's current phase of development.

It is important to clarify ICT as a strategic tool that promotes education and learning on a national level. Used in the right way, ICT as a tool can promote changes to education and pedagogy, result in a more effective education and help adapt education to individual levels and levels of competence.

A national strategy sets up the framework for how schools should develop as a result of using ICT, and it can also be used as a means to control incorporation of developed pedagogical working methods. A national strategy also supports decision-makers on other levels as well as individual teachers in terms of prioritised areas and choices that must be made for using ICT in schools. Strategies for ICT in schools have been produced in several Nordic countries, as well as in the United Kingdom. One example of a strategy from the UK is the e-strategy for using technology in education called *Harnessing Technology; Transforming Learning and Children's Services*.⁷³

A strategy should be accompanied by a number of measurable objectives that can be followed up as well as a plan of action that is linked to ICT and learning. Similar ideas have been addressed in *E-learning Nordic 2006* and *The impact of ICT in Schools*.

73. Department for Education and Skills, 2005, *Harnessing Technology: Transforming learning and children's services*

New types of competencies are needed to meet increased competition and internationalisation of working and social life, and new technology is an important tool in terms of meeting the challenges. There are clear indications that teaching roles are changing – either forced by technology or through actively focused efforts on the part of teachers. The role of the teacher is changing from a traditional leader to a more supervisory role, which means that students are becoming increasingly responsible for their own learning and for completing tasks.

Society is developing, which means that new types of competencies are needed. Using ICT in education and learning offers schools the opportunity to meet these needs. Many studies indicate that ICT impacts on these competencies, especially in terms of group work, independent learning and logical thinking. These types of competencies are not often considered to be core competencies in curricula and syllabi, which is why an analysis needs to be performed: in part to determine suitability and if the competencies can formally be incorporated into future steering documents, and in part to determine various methods to measure the extent to which objectives are attained for each of the competence areas. A similar analysis and proposals are found in the ICT Impact Report and the ITiS evaluation.

Increased level of ICT access and integration

All teachers and students need to have access to computers in order for ICT use to develop positively in schools. Focused efforts on all levels are necessary for students and teachers to have access to computers in schools. Several studies draw the conclusion that using laptop computers, for example, increases motivation and involves students to a greater extent. Mobile technology offers additional options in terms of learning, and student tools can be adapted to individual learning styles and preferences.

Several studies show that students, teachers and parents feel that ICT has a positive effect in terms of improved learning. E-learning Nordic 2006 indicates that there is a connection between availability of computers with Internet connections and learning effects. Headmasters in schools that have the largest number of computers per student have observed that ICT has greatly facilitated integration of new pedagogical methods into teaching.

Continuous access to computers helps teachers feel more secure in their ICT use during lessons and gives them the courage to experiment more and thus helps them integrate ICT into lessons effectively. Many studies also indicate that the impact on learning will increase over time as teachers become more experienced in using computers.

Teachers in several British schools received laptop computers that they were allowed to use both at school and at home; this pronouncedly increased their ICT use when planning, communicating and presenting. Students have been given access to laptop computers in other cases, which has substantially increased their level of understanding and ability in terms of using ICT resources in a suitable manner for school work. Studies such as Using ICT to enhance home-school links show that developing an increased level of co-operation between the home and school also increases the demand placed on teachers to develop their ICT skills. At the same time, ICT skills among teachers increase more quickly when use is integrated with the school's policy and practical workings.

National studies should be initiated to analyse which types of information and services create the most benefit for the relationship between the home and school.

One central conclusion of E-learning Nordic 2006 is the importance of schools and teachers integrating ICT into instruction. ICT should also be integrated generally into the everyday work of schools, for example in administrative work, planning and lesson follow-up, as well as in schools' co-operation with the home. Three out of four Nordic teachers believe they have limited knowledge in terms of using ICT in their lessons, planning and follow-up. The report observes that an evaluation of the methods used for developing competence is needed to determine which ones might be suitable for increasing teacher understanding and knowledge related to ICT in learning.

There are interesting models available, for example from the project in Maine in the U.S. in which each student receiving a laptop computer was supplemented by iTTeams, that is knowledgeable students who helped teachers with the practical aspects related to ICT. A preliminary analysis of successful schools shows that one important factor involved one or more key individuals at the schools functioning as an ambassador and formal or informal leader for the programme.

A model for measuring and promoting electronic maturity and digital competence

Some schools have progressed far in their efforts to integrate ICT and have innovatively linked pedagogy to technology. A model is needed with which to measure and evaluate the level schools have attained in terms of ICT use and ICT maturity; this is linked to efforts to increase digital competence among students and teachers. A national framework is needed to support local efforts related to measurement and self-evaluation. It is important for schools to understand in which ICT use development phase they are in; it is only when it is possible to measure and evaluate individual level of knowledge and development in relation to other schools that strategic objectives can be set for continued development work.

Becta has developed an interesting model that can be used to exemplify this. Their framework⁷⁴ for self-evaluation of development in British schools related to becoming technically mature institutions can be used as a model. The elements included in the self-evaluation are employee development, pedagogical strategies, leadership and control. The framework also includes a number of good examples of work that was done at pilot schools. The school can evaluate its own maturity and development related to ICT as well as take advantage of others' experiences in order to develop further. The ICT Impact Report emphasises similar proposals linked to strategies to develop e-maturity at schools.

A joint international project that includes definitions, measurements and follow-up of digital competence is needed in order to promote skills development in the knowledge society and to achieve the objectives.⁷⁵ The European Parliament and European Council issued a recommendation in December 2006 related to key competencies for lifelong learning.⁷⁶ Digital competence was one of the prioritised areas. The recommendations are directed to all EU countries and are intended to contribute to future-oriented, top-quality education.

The European Commission also held a public consultation in autumn 2006 on media competence in order to edify and improve media competence in the digital age. The consultation will form the basis of a political statement that is planned for autumn 2007 regarding the significance of media literacy.

A common understanding of the concept of digital competence is needed among school administration, teachers and students, and is a prerequisite for measuring and following up set objectives related to competence. An interesting example of how digital competence can be approached comes from Norway. The Norwegian national curriculum has been revised, and in the new curriculum (from the 2006/2007 academic year), ICT is considered to be one of five basic skills. It also comprises part of all subjects on all levels.⁷⁷

Recently published ITU follow-ups to the Norwegian initiative show, however, that the distance between objectives and reality is still significant.

Increased focus on use of digital learning resources and new working methods

ICT is an effective tool that can be used to improve a number of basic skills.⁸¹ ICT enables teachers to individualise teaching based on student working capacity, previous knowledge and his or her preferred study techniques. ICT can also be used to offer personal support

74. Becta, Self-review framework

75. The program Education 2010

76. Recommendation of the European Parliament and the Council on key competences for lifelong learning, 2006/9621/EC

77. Norwegian Directorate for Education and Learning, Kunnskapsløftet

and feedback as well as to follow up student school work. The effects of ICT use on individual performance can be reinforced, but a prerequisite is that teachers and school leaders are aware of which teaching methods work best in different learning situations.

Studies and research on methods that can develop and improve learning should be initiated. Positive examples should be produced to communicate how ICT can be linked to objectives in the curriculum. Support to teachers should be offered as guidance, and digital learning resources should be provided and developed. Important projects have been carried out in several Nordic countries and in England that link digital learning resources to objectives in curricula and syllabi; these efforts can serve as role models for other countries.

Studies from Becta,⁷⁸ for example, show that teachers' pedagogical work should be supplemented with practical advice to enable them to integrate ICT effectively into everyday teaching. Teachers need:

- knowledge related to how a number of learning resources impact on learning processes in a specific subject; teachers should also use their knowledge within their subject areas to select suitable learning resources and software that help them reach educational objectives
- knowledge related to the potential of digital learning resources in terms of the resources being able to change and develop learning within the subject
- a sense of self-confidence when using digital learning resources, which requires continuous ICT use in everyday work
- knowledge related to how specific ICT use changes the way knowledge is communicated and received, which affects the degree to which students feel involved
- knowledge related to how instruction should be organised when working with digital learning resources
- knowledge related to how school work that utilises ICT should be prepared and planned so that student understanding and reflection are challenged and developed.

This means that focused and ongoing work is required in terms of developing teacher competence. The teacher has a great deal of responsibility for his or her own skills development, but the working environment must accommodate this.

Many studies show that school environments that promote development, exploration and change produce students who develop better and who more easily acquire new knowledge. The school administration and organisation must actively support new working methods and pedagogical insights in order for change to take place. The national evaluation of the Swedish initiative ITiS concludes that as a result of ICT being introduced as a pedagogically thought-provoking aid during teacher skills development and development work, that the initiative has encouraged reflection, thought and trying out new working methods.

New concrete experiences form an important basis in terms of changing the way teachers and students approach teaching and working methods. Many teachers learn the new technology in a number of systematic steps, which means that change must be allowed to take time. Thus, realistic objectives linked to the process of changing and developing different school environments must be set. Schools should be given scope to examine and experiment with different methods within certain frameworks. This is also one of the conclusions drawn in the ICT Impact Report.

Final reflection

Futurelab, an independent research institute, writes in its report on future education that "the best way to predict the future education is to build it."⁷⁹ Decision-makers, school leaders and teachers need to know what building blocks will be available to the educational system in the near future in order to understand how they should be used and to develop them for education and learning.

78. Cox et al, 2004, An investigation of the research evidence relating to ICT pedagogy, Becta ICT Research

79. Futurelab, 2007, 2020 and beyond future scenarios for education in the age of new technologies

The overall view clearly indicates that ICT has a positive effect on attainment and performance in specific subjects. However, it is ICT in schools under specific circumstances that creates positive effects. This means that the most suitable technologies and initiatives in terms of supporting student development and learning must be ascertained through evaluation. Work related to investigating and analysing ICT use in schools must be ongoing, and insight into ICT's impact on learning and education needs to increase.

The author of this analysis hopes the report can help interested readers gain a more in-depth understanding and insight into effective technology use in schools.

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Effective use of ICT in schools

The analysis reviews a selection of studies and research reports related to ICT in schools. Based on both Swedish and international research, the aim of the analysis is to gain an idea of under what circumstances ICT/technology can positively contribute to learning and fulfilment of the objectives.

The report emphasises a number of positive effects that result from using ICT in schools such as increased student motivation and independence. Increased levels of student motivation result in increased levels of attention and involvement during lessons, which promotes learning. At the same time, many studies indicate that simply focusing on the technology as such will not contribute to the attainment of positive effects; rather, focused efforts to link technology to a pedagogical concept are necessary.

Personal approaches to teaching also play an important role in terms of teachers being able to create learning opportunities that are communicated via technology. For example, teachers need to be knowledgeable of ICT in order to select appropriate learning resources. They also need to understand how to integrate ICT into lessons and perhaps also how to develop new methods in order to achieve an increased level of integration.

The author of the report emphasises a number of strategic proposals associated with long-term efforts to create a school for the future – a school in which ICT is perceived as synonymous with pedagogical development and creative learning.

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Among other things, Torbjörn Skarin has previously worked as an advisor for issues concerning the link between ICT policy and education policy at the Swedish Ministry of Enterprise, Energy and Communications.

