A systematic review of ICT interventions in learning.

Master thesis
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Abstract

In this study, a systematic review was conducted on 33 different research studies. Only study designs of high internal validity was used. This study examined typologies, categories and effects. The data was collected from a systematic review of 119 different research studies published in 13 different peer reviewed scientific journals. The review process followed three distinct phases. The first phase included an initial search of more than 600 different articles; phase two resulted in a compilation of 119 articles. The studies are dominated by American and UK contributions. The absence of studies examining the effects of social media or web 2.0 applications is noticeable. Fourteen studies were subjected to a calculation of their mean effect sizes. Their effect sizes ranged from ES=0,009 to ES=0.64. The pooled mean was ES=0.20. This is considered as a low effect size. This confirms the findings of other studies on effects of ICT on learning thereby enhancing their external validity. Implications are discussed.

Preface

The way towards this master thesis has been quite a long journey. I remember my first year at teacher training college, and my first meeting with computers. I was supposed to write an assignment with a word processor, I think it was a version of Word Perfect. This was back in 1992 and I thought it was a waste of time. Some two years later, a fellow student demonstrated something she called Internet, I was gobsmacked and got myself a computer right away. I bought an Olivetti machine with an 80mb hard drive and a 14 400kb/s modem. I miss that modem sound even today. In 1997 I was asked to be the school's ICT manager, and I foolishly accepted. I really didn't have a clue, but neither did anyone else. As the saying goes, in the land of the blind, the one eyed is king. My interest in the technology itself faded quite soon, but I found new interest in pedagogy and all the possibilities this new technology brought into my working life. I soon came to the conclusion that ICT was not really the mother of all pedagogical inventions; it was quite simply a new tool to be reckoned with, or more precise, a plethora of tools. Some of my fellow colleagues embraced it, others tried to avoid it, but it just snowballed from there and with the latest Norwegian teaching plan from 2005, ICT competence was considered to be as fundamental as writing and reading. Is ICT competence of vital and fundamental importance for learning today? Probably not, but it does provide us with some really interesting and powerful tools augmenting learning.

Along the way one question kept popping up, can we measure the added value of ICT? We have invested a lot of money in our schools and a great deal of money into ICT. Bottom line, is it worth it?
It is hard to tell, the research into the impact and effects of ICT is fragmented and it is difficult to get a coherent picture. The complexity of learning environments seems to be a daunting challenge for any researcher and the diversity of different technologies and their affordances makes the picture blurred it seems. Can we paint a coherent picture then? We are dealing with so many different variables when we try to describe and explain a complex matter as a learning process, a learning outcome or a learning

environment. A fully coherent picture is most likely not achievable, so we have to address this in some other way maybe. When I started to look for answers, I soon found a lot of questions and not very many answers. So in many ways, this master thesis is just a small search for big answers and perhaps even more, a discussion about ICT and how we perceive it.

The completion of the master thesis marks the end of a lot of work, frustration and joy! It has been a long ride, it is tough to combine studies with a full time job, a new born baby, and it is tough to combine studies with a full time family. But the biggest joy of all has been the experience of learning, learning something new! I want to thank all the people at Høgskolen Stord/Haugesund that have helped me along the way, especially Lars Vavik that saved my skin in the last minute... A very flexible employer made it possible and of course, the patience of those at home.

Thanks Patricia! You have supported me immensely and cheered me on the whole time! Without you, no thesis!

Jakob Sletten 4th March 2010.

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Chapter 1 Background

1.1: Problem area

The use of ICT in education has drawn a lot of attention for different reasons. We have spent a lot of money on it, we have implemented it on a large scale and we are still not quite sure on how to put it to good use. Students today are more accomplished using ICT than previous generations. It has become an integrated part of their daily life. But are students today learning any better with ICT and are the students becoming smarter as a consequence? Have we really managed to draw on the power of ICT for educational purposes? Evidence has been scarce and often connected with specialised use of technology and specific learning activities. Because of this we have difficulties making sensible generalisations of the evidence. This has made decision makers and stakeholders second guessing themselves; they want to know what that works and what that doesn't work.

In order to get hold of more certain answers, Evidence Based Research (EBR) has become increasingly popular as a mean for providing sound scientific knowledge, or to be more precise, a mean for putting scientific evidence into practice. An often used research method is the systematic review. By reviewing a cluster of scientific studies, the supported evidence can be more thoroughly scrutinised. In other words, the systematic review seeks to identify, evaluate and suggest use of the empirical findings at hand based on a series of studies. Decision makers and stakeholders are increasingly asking for this kind of reviews. A recent example is the report "Lærerkompetanser og elevers læring i førskole og skole" {{221 Sven Erik Nordenbo 2008}}This review was ordered by the Norwegian Ministry of Education in an attempt to map important teacher competencies that mattered in the classroom. The final report was based on 55 scientific studies of high quality and offered clear answers to what competencies they found to be important. This is of course a powerful tool for policy making, but does it offer the whole picture, or to be more precise, does it capture the complex interactions and patterns in an authentic learning environment?

There is no easy way to determine learning effects due to the use of ICT in a learning environment or isolating the different agents of change, be it technology, the student or the teacher. Learning is a complex process and should be treated as such. This does not mean that we can't observe such effects and determine their relations, only that it is difficult. This suggests that we have to look at learning environments using ICT in a systemic way; we are not analysing single variables but analysing the interaction between them and the patterns they create (G. Salomon, 2007).

1.2: What do we know?

So what can be said about the bigger picture? Two well known discourses about the effectiveness of ICT in learning are well suited to establish the premises for this paper. The Kozma vs. Clark discourse (Robert B. Kozma and Richard E. Clark) is often viewed as a foundation for most of the debate coming later. The other discourse was the well known criticism coming from Larry Cuban and Todd Oppenheimer at a later stage.

In 1983, Clark published an article called *'Reconsidering research on learning from media'*. Here Clark stated that media did not influence learning under any circumstances. Seven years later Kozma took the opposite position and stated that media indeed influence learning in his article *'Learning with media'.* In addition Kozma reframed Clark's original question, which mostly concerned itself with media attributes, and added issues about whether cognitive properties of technology, processing capabilities and symbol systems influenced learning. Clark stated no, Kozma stated that it did. This discourse went into a stalemate and was not solved. The debate is still going on to a certain degree, but has changed character. One important influence in this respect was the input from several other contributors in a special issue of the journal *Educational Technology, Research & Development* devoted to the Clark/Kozma debate in 1994. This discourse became very influential as it broke the deadlock of the Clark/Kozma schisma. I have chosen to include a full synopsis more or less because of this.

Steven M. Ross: As the editor of ETR&D, Ross introduced the issues involved in the debate and brought forward his concerns about the "misconceptions surrounding the

media effects issue").

Eldon J. Ullmer: Ullmer offered "an alternative value framework for guiding research on the effects of modern interactive technologies in complex learning environments").

David H. Jonassen, John P. Campbell, and Mark E. Davidson: Jonassen et al., restructured the debate to "learning with media" and stated that "this debate should focus less on media attributes vs. instructional methods and more on the role of media in supporting, not controlling the learning process".

Gary R. Morrison: Morrison felt that "rather than reframing Clark's question, it seems more productive to consider the effectiveness of the whole unit of instruction rather than the individual components". Morrison concluded that "instructional technology researchers continue with basic, applied, and development research to determining the most effective strategies for accomplishing a given task" [emphasis added].

Robert A. Reiser: Reiser wrote as an instructional designer and expressed interest in research that will help him identify effective "instructional conditions (methods and media)") to solve instructional problems.

Sharon A. Shrock: Shrock expressed a deep concern "about increasing indications that our field (educational technology) is being redefined as the application of electronic delivery systems" and discussed consequences of acting on either Clark or Kozma's position.

(Bastian. M, 2000)

Later on, the criticism from Larry Cuban (Cuban, 2001) and Todd Oppenheimer (Oppenheimer, 1997) are well known and created much debate. They both found that ICT had a negative effect on students' performance. This created quite a stir and the debate reached well beyond research circles and out to the general public. Cuban's report was later criticized on the basis of not taking account of teacher or student

characteristics (Voogt & Knezek, 2008).

Researchers are reporting that it is difficult to find unambiguous positive effects by the use of ICT in learning - *The Impact of ICT on Student Performance in Higher Education: Direct Effects, Indirect Effects and Organisational Change,* (Dahmani & Youssef A. B, 2008). We also have to look to the factors we already know make a difference in student performance, student's characteristics, educational environment and teachers' characteristics. The same researchers point to a lack of empirical evidence and contradictory evidence, they offer several explanations. ICT is a form of general purpose technology and immature by nature. Its affordances are not fully understood and can explain why we are not seeing any significant changes.

We see that large studies observe a negative correlation between use of ICT and student performance. (Wainer et al., 2008), the same are reported by Fuchs and Wossman {{222 Fuchs, T 2004}} in an assessment of the *PISA* 2000 findings. The *PISA* report suggested originally that increased use of ICT correlated with increased school performance, but when they kept other variables constant, no such correlation was found.

A Norwegian report from 2008 '*Bare bok gjør ikke klok'* (Albriktsen, Haugnæss, & Nafstad, 2008) state that research regarding learning effects with ICT is ambiguous. The report reefers in particular to two other reports, the *ImpaCT-2* study (Colin Harrison, Chris Comber, Tony Fisher, Kaye Haw, Cathy Lewin, Eric Lunzer, Angela McFarlane, Diane Mavers, Peter Scrimshaw, Bridget Somekh, Rob Watling, 2002) and *E-learning Nordic* (Pedersen & Rambøll Management, 2006).

The ImpaCT-2 report stated that ICT impacted positively on student performance in English, less so in science and had no effect on math performance. It also had positive effects on attainment levels among school children in science and in Design and Technology. It reported positive effects on achievement by the use of whiteboard technology, especially among low level achievers. The E-learning Nordic report is only dealing with perceived values and affordances of ICT in learning. The teachers perceive

a positive effect on both weak and strong students, basic writing and reading skills. But we have no way of telling what the net ICT effect is from this report, we assume it works.

Another important Norwegian report, *ITU-Monitor* 2007 (Arnseth, Hatlevik, Kløvstad, Kristiansen, & Ottestad, 2007) says nothing about learning effects, but a lot about use of ICT in schools. There is one very interesting fact though, the teachers are having problems embedding and incorporating ICT meaningfully, coherently and systematically in their teaching. The ICT Impact Report (Balanskat, Blamire, & Kefala, 2006) cites both the ImpaCT-2 and E-learning Nordic reports.

SITES 2006 report that ICT use is low in science and math teaching (Plomp, Pelgrum, & Law, 2007). The same fact is reported on in the ImpaCT-2 report. This is interesting regarding the findings on math performance. But again, nothing is reported on ICT learning effects. At best we observe weak causal learning effects by the use of ICT; we see that there are some correlations between ICT and student performance, but they are not strong ones and other variables seem to dominate the learning outcomes. This is again supported by findings in a recent Norwegian report *"Elevenes læringsutbytte: Hvor stor betydning har skolen" (Grøgård J.B, Helland H, & Lauglo J, 2008).* This report only observes very weak effects by ICT in schools, but their variables regarding ICT are quite coarse and are just measures of work related and infrastructural related resources at each school.

In the report '*Lærerkompetanser* og *elevers læring i førskole og skole' (Nordenbo, Larsen, Tiftici, Wendt, & Østergaard, København 2008)*, they tried to map which teacher competencies that contribute to learning. They came up with three main characteristics regarding important teacher competencies with significant effect on learning outcomes. 1. Social competence in the meeting with the student (social relations competence). 2. The teacher should be a visible leader, leading the group through their learning by stating clear rules and clear goals. The teacher should guide the student towards creating own rules and learning autonomy (rule competence). 3.

The teacher should have general and specific didactic competence (didactics competence). These findings are supported by the findings of John Hattie (Hattie, 2009a). He summarized a substantial amount of different meta-studies, aggregating and synthesizing some quite interesting results. He treated the results from thousands of reports statistically and came up with a table of different constructs and their effect sizes. Among the 30 most effective constructs with an effect size (ES) of 0.58 and upwards, the number of direct teacher related constructs was 10. Technology related constructs was not among top thirty. The best technology related construct was *'Interactive video methods'* with an effect size of 0.52; that is just above average. *'Web based learning'* had an effect size of 0.18 and *'Television'* had an effect size of -0.18, in other words, a negative effect on learning.

1.3: A rationale

This paper is based on the following assumption:

The lack of coherent knowledge about use, effects and implementation of ICT in learning is not based upon lack of evidence, but rather a lack of systematized, synthesized accumulated data.

Grounded on existing evidence, there is a certified need for further investigation into the added value, impact and effect of ICT-interventions on learning. Thousands of research studies are published, but have in many ways not been able to draw a coherent picture of how ICT impacts learning. However, we do have interesting and accumulated result in John Hattie's study *Visible Learning: A synthesis of over 800 meta-analyses relating to achievement* (Hattie, 2009b). His study produces very interesting results and represents a very sound approach to the gathering of general evidence. He concludes in short that the effect of computer assisted instruction is low (with a mean effect size of 0.37) unless the technology is paired with other instructional methods. This view is now also echoed from top EU officials. During SADEs (Swedish Association for Distance Education) autumn conference early October 2009, Godelieve van den Brande from the EU Commission stated that research into

effects of ICT in learning had not produced the answers they were looking for. She stated that now they had to concentrate on learning processes, teaching practices and teacher training. Van den Brande made a clear connection between teaching practices and the impact of ICT. She based this view on preliminary findings from the STEPS project (STEPS, 2009). The same picture is being drawn by other educational researchers:

'Many decades after the introduction of ICT into classrooms there are still unanswered questions about the impact of technology in the long and short term on students' learning, and how it has affected simple and complex learning tasks'

"Furthermore we do not know if previous research studies have used research methods that matched learning objectives to instruments/procedures. Many previous studies are vague as to the actual measures used but we can infer that standardized tests were a frequent measure. In other instances, ad hoc analyses, with criteria that may have varied from analyst to analyst and were not "blind" analyses were certainly used to measure "success." All of these limitations and uncertainties and many more point to the need for a thorough, rigorous, and multifaceted approach to analyzing the impact of ICT on students" learning" (Cox & Marshall, 2007).

This poses two main challenges:

- How do we gather, compile, synthesize and analyse evidence and data in a coherent way?
- How do we determine the effects of ICT interventions?

This study seeks to examine recent research into the area of ICT and learning and presents an overview of research typologies, technology typologies and what kind of common features there are to be found in the research studies examined, thereby making a small contribution to our common knowledge base.

In order to compile, systematise and analyse research material, this study presents an

evidence gathering method and explains the background and origin of the evidence based research approach (EBR). The method of the systematic review is used and a narrative synthesis conducted.

In order to determine effects, a small scale effect size calculation is conducted and its implications in relation to a larger study are discussed.

ICT is a generic concept, not a technology per se. ICT is a plethora of different technologies and they all have their own set of properties and affordances. This mean that these technologies have to be identified and explained, typologies and affordances worked out. ICT can first be incorporated into learning processes when there is a connection between affordances and learning activities. It is in many ways a case about scaffolding, what sort of technology suits a certain learning activity and how does this translate into achieving certain learning goals and learning outcomes. This study presents how different technology typologies can be grouped in order to determine their presence in recent research.

Social media, web 2.0 applications are increasingly gathering momentum. They are being discussed for learning purposes and fit in nicely with the mainstream constructivist learning approach. This study incorporates a model where technologies are explained with a set of different affordances. The six different affordances are: *access, presence, expression, creation, interaction and aggregation.* (Siemens & Tittenberger, 2009) These affordances are originally attributed to social media and a 'web 2.0 paradigm'. How is this applicable over a range of technologies?

The systemic review is about uncovering heterogeneity and homogeneity in a data sample, it is a powerful tool. Is this study observing similarities between studies, is there contrasts and do we find confirmation of evidence?

1.4: The study and research questions

In order to examine the topics presented in the rationale, this study raises three main research questions:

Question 1: What kind of technology is evident in recent research into ICT and learning?

Question 2: Is it possible to identify a common feature among the studies in the review?

Question 3: Is this study confirming or contrasting other studies?

This study presents and uses the systematic review as a tool for compiling, synthesizing and analysing necessary data in order to answer the research questions. The systematic review was deemed appropriate for this purpose, and collects its data from more than hundred different studies published in 13 peer reviewed scientific journals.

1.5: Structure of the study

The following section describes how the report is structured, why it is structured in such a fashion and how relevant background material and theory fits in.

- *Chapter one: Background (problem area, relevant research, a rationale, thesis and research questions)*

- *Chapter two: Theory (validity, evidence based research, the systematic review, ICT affordances)*

- *Chapter three: Method (choice of method, tools, procedures, the review process and research bias.*

- *Chapter four: Presentation of data (tabulated data)*

- *Chapter five: Analysis of data (explanation and key findings)*

- *Chapter six: Conclusions, implications and suggestions*

- *Appendix, list of tables, figures and references.*

1.5.1: Chapter 1, Background

Chapter one is written with the aim of giving the reader a heads up regarding the field of research and my reasons for researching it. The first part (1.1: *Problem area*) is a description of the problem area, fitting it into the bigger picture, a larger context. The next part (1.2: *What do we know*?) describes the area of research into ICT in learning and the relevant discussions, issues and research associated with it. Here the main discourses and interesting views on research are laid out, recent history is emphasized. The issue of the current knowledge gap is given weight. The following part (1.3: *A rationale*), puts forward the main reasons for researching the area all together, giving the thesis purpose and reason. I am also trying to explain some key concepts addressed in the study. The last part of the chapter (1.4: *The study and research questions*) presents the three research questions and a very brief description of the research approach used for the data gathering and the synthesizing of compiled data. Section 1.5: *Structure of the study*, is a brief account of the study's different sections.

1.5.2: Chapter 2, Theory

Chapter two is a detailed account for all the relevant theory, theoretical and practical measures, conceptual frameworks and concepts used to develop and underpin the study. Important concepts are outlined and explained.

Section 2.1 discusses the basics of the evidence based research (EBR). This section is an account for the origin, implementation and characteristics of EBR. Secondly it discusses the principles of the systematic review and its characteristics including a short description of the meta-analysis.

Section 2.2 discusses the basic concept of validity, a central concept for the foundation of EBR and the systematic review.

Section 2.3 discusses the Contextualisation of learning and the complex nature of learning environments. An important understanding when researching learning effects and describing a learning environment's multiple constituent variables.

Section 2.4 discusses the "action potential" and affordances of social media and web2.0

Section 2.5 discusses the effects of ICT, and presents a powerful study of importance

1.5.3: Chapter 3, Methods

Chapter three is a detailed description of the research method in use (the systematic narrative review), the different methodical considerations and choices , the development of different tools, the development of procedures, development of constructs and an account for possible research bias. This chapter is a stage by stage account of the review process.

1.5.4: Chapter 4, Presentation of data

Chapter four presents all relevant data across all the included studies. The data is tabulated or visualized to increase readability. Chapter four builds upon the tabulated and synthesized data from the included studies. This chapter presents and explain key findings within each category of data.

1.5.5: Chapter 5, Conclusions, opinion, implications and suggestions

This chapter summarizes the key findings and put them into perspective, implications and suggestions for further research are discussed

1.5.6 Appendix, list of tables, figures and references

Chapter 2: Theory

My area of research is coined by David C.Berliner in his article "Educational Research: The Hardest Science of All":

"The "evidence-based practices" and "scientific research" mentioned over 100 times in the No Child Left Behind Act of 2001 are code words for randomized experiments, a method of re-search with which I too am much enamoured. But to think that this form of research is the only "scientific" approach to gaining knowledge—the only one that yields trustworthy evidence reveals a myopic view of science in general and a misunderstanding of educational research in particular." (Berliner, 2002)

The theory chapter tries to capture the main aspects of this study's theory-foundation.

2.1: Evidence Based Research and the systematic review

The EBR approach is very much in demand of study designs of high internal validity, and the quality of the evidence presented is based partly on its degree of internal validity. "The hierarchy of evidence" is a measure developed in order to establish the degree of internal validity, the degree of "evidence quality". The purpose if this research approach is one of making generalisations, EBR seeks to identify practices, describe a situation or identifying patterns and interrelations.

The idea of Evidence Based Research (EBR) is not new; this kind of research has an established track record in medicine and healthcare. EBR has been used for the rigorous testing of health programs, effects of certain treatments and evaluation of practices. We can track the development of EBR more than hundred years back in time (Petticrew & Roberts, 2006). The evidence gathering of an EBR approach is done by a systematic review of literature, practices or scientific evidence.

Figure 1 The systematic review
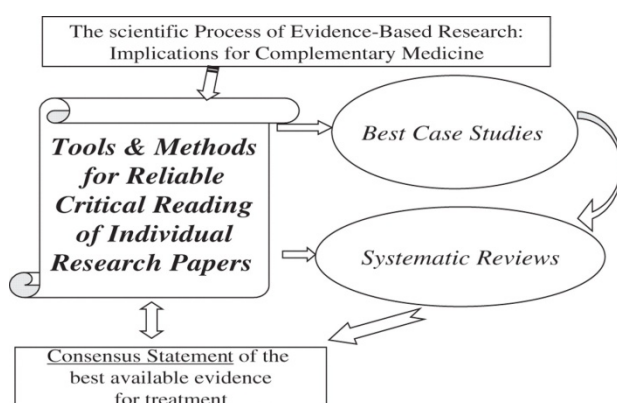
(Chiapelli, Cajulis, Edgerton, Prolo, Rosenblum, 2006)

The strength of the systematic review depends on numbers, the sample size; this makes it possible to draw conclusions that are relevant, that are having external validity from studies with high internal validity, often a problem in research. We can characterize the systematic review as a kind of meta-research, the quality and the outcomes depend not only on the review itself, but on the work of other researchers and their work quality. This makes validity measures even more important. A systematic review will increase its validity with an increased number of included studies (*Sample size*), but validity will also depend on the quality (validity) of the individual study and their appropriateness (*Relevant studies*) related to the research question. Finally, the validity is of course linked with conclusions that should be founded on sound evidence (*Synthesizing of evidence, conclusions).* The total review validity (both internal and external validity) depends on these key factors, and the process can be illustrated with this simple figure:

Figure 2 Total review quality
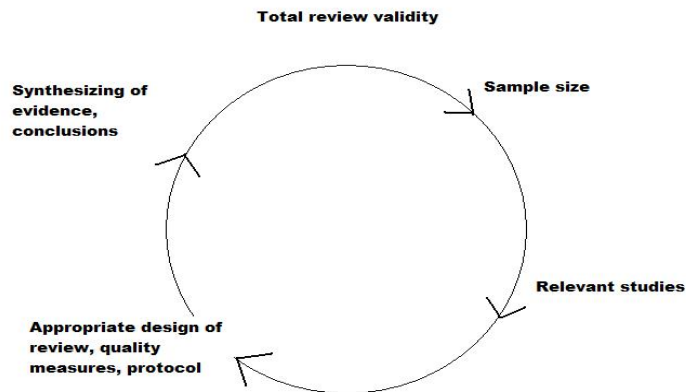
Evidence Based Research can be described as: "...the conscientious, explicit and judicious identification, evaluation and use of the best evidence currently available." (Chiapelli, Cajulis, Edgerton, Prolo, Rosenblum, 2006)

The systematic review is a method of gathering, analysing and synthesising scientific evidence for later implementation into the field of practice as Evidence Based Practice (EBP). EBR has made a major impact within medicine and healthcare, a simple search on the web reveals that a large number of hits are linked to medicine and especially healthcare. It has become a vital part of establishing healthcare and nursing as a science based profession.

The systematic review (SR) is often divided into three subtypes. The first one is the systematic (literature) review, the second one is the meta-analysis and finally we have the narrative review. They are not mutually exclusive, but can be combined.

The systematic (literature) review: Are reviews that strive to comprehensively identify, appraise, and synthesise all the relevant studies on a given topic. Systematic reviews are often used to test a single hypothesis, or a series of related hypotheses.

Meta –analysis: A review that uses a specific statistical technique for synthesising the results of several studies into a single quantitative estimate, a summary effect size.

Narrative review: The process of synthesising primary studies and exploring heterogeneity descriptively, rather than statistically.

(Petticrew & Roberts, 2006)

The choice of review methodology will be determined by the scope, the field of practice, the research questions and the overall purpose of the review in question. The single most important aspect of the systematic review is that it is designed to establish external validity, even if the primary studies are of high internal validity, thus making it a powerful tool.

2.2: The review methodology

The review process is characterised by four phases, refining the research question/s and defining the boundaries, selection of sources (based on the scope of the review) selection of material (inclusion and exclusion factors) and finally, synthesising and aggregating evidence. The following items are suggested to be relevant for assessing the quality of trials:

- The relevance of the research question
- The internal validity of the trial (the degree to which the trial design, conduct, analysis and   presentation have minimized or avoided biased comparisons of the interventions under evaluation)
- The external validity (the precision and extent to which it is possible to generalize the results of the trial to other settings)
- The appropriateness of data analysis and presentation
- The ethical implications of the intervention evaluated

(Petticrew & Roberts, 2006)

The screening criteria will often be indicators of assessed quality and developed to keep the research material within the right scope of the review overall. The literature describes seven stages in the review process (Petticrew & Roberts, 2006), but I have

chosen to simplify the structure somewhat, incorporating one or more stages into a specific phase. This is done because we observe four main specific phases of activity in order to conduct a review:

- Defining the scope and research questions for the review

- Decide on inclusion and exclusion criteria, defining boundaries

- Searching, compiling and systemisation of studies

- Aggregating and analysing evidence

These four phases will be described in detail in the review protocol (described in section 2.3.2). I have added more weight to the assessment of controlled trials and related study designs. I have chosen to do this on the background of the review process of this thesis and the inclusion and exclusion criteria developed for it (only controlled trials and certain quasi experimental study designs were included).

2.2.1: Refining the research question/s and defining the boundaries

The starting point of every quest for insight or knowledge is a question or questions related to that very area of interest. This is also the starting point for the systematic review (SR); there is of course something we want to examine closer. The research questions have to precise, relevant, measurable and appropriate regarding the use of the systematic review as a research methodology. The first question asked should be: is the systematic review the right research tool to answer the research questions? If not, you should consider other tools and methods available. There could be that a new primary research study is a better approach, or you have to determine if there already exists good research/systematic reviews in this area. If so, there is no reason to put down the efforts necessary to conduct a new review.

The research question/s has to be balanced between not being too narrow or limited in scope and being too vague or broad. The research questions must have the right focus and answer the right questions in a proper way. A not uncommon way to achieve

this is to involve the potential users of the review. They should be consulted early on to find out their exact need for information. For example, there is no point in doing a systematic review of the literature on parents' need for childcare, if what is really needed is a review of what kinds of childcare are associated with the best outcomes for children, or perhaps, a review of effects of childcare on parents' and children's lives (Petticrew & Roberts, 2006).

Another problem associated with the SR is when to do a review, when the field of knowledge is immature and the access to studies are limited or later, when there are many primary studies to review? There is no exact answer to this; a review in an immature field can help finding knowledge gaps and direct future research. Reviews later on will of course have the advantage of being able to draw knowledge from a large pool of studies. There is no need for duplicating a review unless it is clear that the preceding review has flaws, bias or simply is out of date.

Another key element is to develop a detailed protocol for the review. This protocol includes the overall scope, a description and a rationale for the question/s, a description of the proposed methods, inclusion and exclusion criteria, tools and finally, a description of constructs, typologies and categories. Such protocols ensure a homogenous, transparent approach, especially if more than one researcher is involved. It is also important for the reliability of the review, to what degree the same results can be duplicated under the same circumstances later. It also functions as a quality screening vehicle. Perhaps the most important bit regarding the protocol is the development of inclusion and exclusion criteria when studies are retrieved and compiled. These .The main issues developing the criteria will typically be of scope, appropriateness and validity.

When the research questions is properly defined and the scope of the review firmly set, the process of selection sources and deciding on what studies to include in the final review can begin. This process is described in the next two sub chapters and is also a description on how to develop the protocol for inclusion and exclusion criteria. The inclusion and exclusion criteria are applied in several specific steps along the way creating a pool of studies to include in the final review. These steps are associated with

selection of sources and selection of studies. This protocol should address these key elements:

- The scope of the review (There is no point in searching for studies on breast cancer if the research questions are dealing with cancer in the prostate or other male characteristics, or if the research is not on the effects of ICT interventions on learning, but rather on other learning interventions where ICT is just another part of the learning environment).

Figure 3 Intended scope
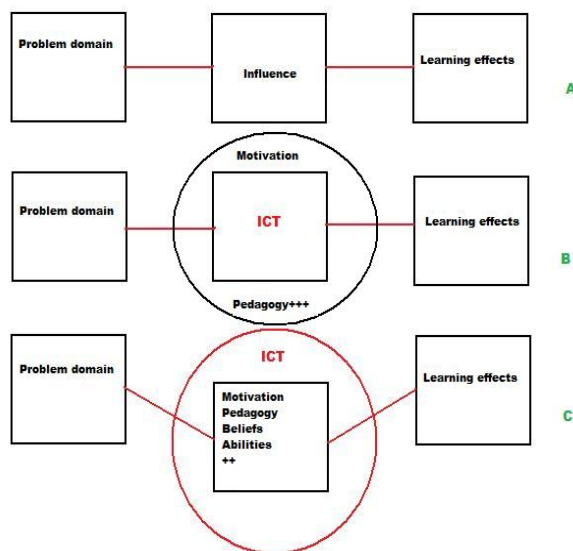
Figure A shows just how a certain treatment (here called influence) impact on learning, thereby having an effect. Figure B shows how ICT treatment is the intended measured variable. Figure C shows articles rejected because they didn't measure ICT as an intervention, but other interventions, still in an ICT rich environment. (Sletten J, 2009).

- Determine where to look for studies (Which journals to screen, identify "grey literature", relevant databases etc...)

- Consideration of validity, relevance and quality issues (This includes the concept of a "hierarchy of evidence")

- How to retrieve the information and how to handle and store it (How the retrieval process is done, including tools)

- Aggregating and analysing data (choice of statistical tools, development of variables and constructs, formatting of data...)

2.2.2: Selection of sources

The main challenge is more often to tackle an information overload than handle a lack of relevant studies. The most important question is a question of quality. The element of quality in this regard, consist of two key parts, one of relevance and one of trustworthiness. The issue of relevance is simply to look for studies at places where your research questions are likely to be addressed and within the scope of the review. The issue of trustworthiness is an assessment of quality assurance and seriousness behind the primary study designs and the publishing body.

Two important concepts to be aware of are the concepts of *sensitivity* and *specificity*. These two concepts are found in any research terminology and relates most often to the population of a study, but in the case of a systematic review that relate to the body of literature available for retrieval. The main aim is of course to get relevant literature not to retrieve everything. A sensitive search is one that retrieves a high proportion of the relevant studies available to us. A specific search retrieves a low proportion of irrelevant studies. There will often be a trade-off between sensitivity and specificity. This compares to shooting with a shotgun (sensitivity), where you are likely to hit a larger surface with shooting with a sniper rifle (specificity), where you are aiming at a specific point. These two approaches can of course be combined successfully.

We divide the sources into two large groups, "ordinary" sources and "grey literature" (Petticrew & Roberts, 2006). Ordinary sources are literature published through readily accessible channels such as large databases, recognized scientific journals (peer reviewed), digital and analogue alike. "Grey literature" is not published through journals and may not be indexed by databases. These are sources that simply will not appear through ordinary search routines. Such literature can consist of book chapters, abstracts of dissertations, conference proceedings or ongoing research. When searching in databases, the researcher has to develop a search strategy. A search

strategy often involves a word string (synonyms), defining each element of the search: type of intervention and type of outcomes. The population can of course be defined by both type and size and the type of study designs are defined by listing the different types.

2.2.3: Inclusion/exclusion of studies

There are a whole lot of considerations to bear in mind when we are setting up the procedures for the selection of our studies and our protocol for inclusion and exclusion criteria. The single most important consideration is again one of quality. The systematic review defines quality quite detailed and the most important element is the assessment of validity. Validity is paramount regarding quality in a systematic review. For this purpose the "hierarchy of evidence" is used. Hierarchy of evidence:

- Systematic reviews and meta-analysis
- Randomized controlled trials with definitive results
- Randomized controlled trials with non-definitive results
- Cohort studies
- Case-control studies
- Cross sectional studies
- Case reports

Notice that this model does not include any qualitative study designs; other hierarchies do include them and rank them near the bottom. This varies with different literature. The hierarchy is in other words guiding us towards the studies with the strongest evidence, studies with the least susceptibility to research bias. We have to match the research questions with the most appropriate study designs answering our questions. There exists guidelines and they are based on assumptions on validity and relevance for different types of study designs. I use the word assumptions because a study design well suited in theory for a certain research question, can be poorly designed or executed, ruining the initial benefits for that particular study design.

Figure 4 Appropriateness of different study designs

Research question	Qualitative research	Survey	Case control studies	Cohort studies	RCT's	Systematic reviews
Effectiveness of interventions				x	xx	xxx
Process of service delivery	xx	x				xxx
Salience	xx	xx				xxx
Safety	x		x	x	xx	xxx
Acceptability	xx	x			x	xxx
Cost effectiveness					xx	xxx
Appropriateness	xx	xx				xx
Satisfaction	xx	xx	x	x		x

(Petticrew & Roberts, 2006)

If your questions are about effectiveness of interventions, *randomized controlled trials* (RCT's) are deemed the most appropriate study design for this particular type of questions. RCT' rank highest in the hierarchy of evidence with high internal validity (apart from the systematic review itself). This is an effective type of study design if we are not examining too many variables. This is the type of design closest to what we normally would call a true experiment. In research into interventions of technology on learning it is difficult to control the number of variables influencing the outcome of the RCT and rule out the variables that don't have a bearing on the effect all together. A RCT may run into the problem of being very narrow in its scope due to the quest for high internal validity, thus making it hard to tell if the outcomes can be duplicated within another setting or with a different population (generalisations/relevance).

Another issue regarding study design is that by choosing several types of design you are in fact triangulating your review. Such a measure will to some extent counter the different properties of bias associated with the different study designs.

It is important to specify outcomes that the review is seeking information on. For reviews of effectiveness, the intervention may have a range of impacts on those

receiving it (Petticrew & Roberts, 2006). These impacts can be divided into primary outcomes and secondary outcomes. The primary outcomes will be the effects we are most looking for and match our research questions best. The secondary outcomes can be short-term outcomes, outcomes that are easier to measure and verify within the time-span of the review process or project. It can be necessary to synthesize data based on these short-term or "surrogate" outcomes, because of the lack of long term or primary outcomes. This will of course affect the quality of the review. We should be particularly careful if we want to establish causally relations, the secondary outcomes can be related to the primary outcome but not enough to draw causally conclusions. In social science few relationships are simple and unifactorial (Petticrew & Roberts, 2006).

2.2.4: Aggregating and synthesising evidence, the narrative review

We find three main subtypes of reviews:

- The systematic (literature) review: Are review that strives to comprehensively identify, appraise, and synthesise all the relevant studies on a given topic. Systematic reviews are often used to test a single hypothesis, or a series of related hypotheses. Both qualitative and quantitative data can be explored.
- Meta –analysis: A review that uses a specific statistical technique for synthesising the results of several studies into a single quantitative estimate, a summary effect size. Quantitative data is being explored.
- Narrative review: The process of synthesising primary studies and exploring heterogeneity descriptively, rather than statistically. Both qualitative and quantitative data is being explored.

The review process of this study can be described as a narrative review. Aggregating evidence is very much a question of the use and implementation of appropriate tools. These tools are designed to help the researcher to sort the results and evidence into

meaningful categories supporting the synthesizing process. Such tools are computerized to a large extent today. There exist many different tools, some are specialized research/statistical tools, others are generic, but applicable. Such tools are often an integrated part of the review protocol. The tools are of course set up and adapted to the needs of that particular review, addressing the research questions, the exclusion and inclusion criteria and the different categories and constructs developed for the review.

A synthesis of studies in a narrative review can be made in several ways, the most commonly used approach in reviews of effectiveness is made of three steps:

1. Organizing the description of studies into meaningful and appropriate categories

2. Organizing the findings within each separate category

3. Synthesizing these findings across all the included studies

There is no definitive approach regarding organizing the studies into categories, it depends largely on the research questions and the properties of the area examined and reviewed. A common practice is to arrange the studies included into different tables, these should include a description of the studies, their populations, methods, and results. This will give the review transparency. Tables can give the reader a clear picture of which data has been extracted from which studies and what sort of contributions each study has made to the final synthesis. Each table should include a short narrative summary of results giving the reader a proper description of what the table show. It is important however, to underline that tables alone don't constitute a complete synthesis. To create a full synthesis one should account for the different existing biases and other issues related to a critical appraisal process which may affect the interpretation and outcomes for each study.

By carefully tabulating all relevant categories, the researcher can make assumptions based on the evidence present. The big problem is however, that regardless of how carefully we have designed our review and organized the data, no study is exactly

similar and not comparable. We are really not looking for hard evidence, but are more on the lookout for trends and probability. Numbers (the pooling size of the studies available and the final number of studies included) are really a quality measure in itself. A trend is not really a trend before we can observe it several times over across different studies. A commonly used research approach is the meta-analysis, a statistical synthesis of quantitative studies. The meta-analysis gives us a tool for comparing different studies, weighting the different information in order to create a comparable statistical measure called effect size (ES).

2.3: The validity issue

The concept of validity is a key feature in an EBR approach so the concept warrants a brief presentation. Validity as a word means just "truth", the lack of ambiguity. So validity is really a case of trustworthiness, "why should we believe your research?" The word validity is found in every book and paper on research methodology and here it is given a very specific meaning. Validity is a key concept in research terminology. Validity is to what degree the researcher actually measures the intervention he intends to measure. Another definition of validity is that it equals lack of bias. Bias is factors that blur, distort and alters the results of the research study. An infamous and quite recent example was the measurement of fog at Hurum during the location process for the new airport for Oslo, Norway. The debate was very heated and the location of Hurum hotly contested. Opponents of the Hurum location were smearing the instruments with Vaseline in order to skew the test results. The measurements were of course dead wrong, an exotic example perhaps, but quite illustrative on the point of bias.

It is difficult to discuss the concept of validity without knowing the concept of reliability. Reliability is the consistency of a set of measurements or measuring instrument, describing the properties of a particular study design or test. Reliability is a precondition for validity, but reliability does not imply validity alone. This can be illustrated by an example:

A thermometer outside give us the readings -10, -20, - 5 and -15 C° during ten minutes a cold winter night. This will very soon point us to the conclusion that the "test vehicle", the thermometer, is faulty and not reliable. If the readings are constantly at - 10 C° during the same test interval, we would conclude that the thermometer is indeed reliable. But if the true outside temperature is -15, the results would simply not been valid, but still reliable. If it had read -15 each time during the test interval, the results would have been both reliable and valid. Reliability is *necessary but not sufficient* for validity. A simple model can look like this, V (measured variable) = true value + measurement inconsistency. Reliability is in other words a measure of how precise and consistent a test or study design is created and conducted.

Another word for reliability is internal consistency and there are three ways of assessing it. The first way is an ordinary quality control of the data, how precise relevant questions are formulated in order to track sources of error and how precise the data collecting is. Test –retest methods are frequently used in order to ensure internal consistency. Test-retest is a way of measuring the degree of correlation between two or more administrations of the same measure. A third method is to measure the mean correlation between indicators in cross sectional data sets. This is most frequently measured by Cronbachs alpha (α) (Ringdal, 2007). There are a lot of factors that can be considered as threats to reliability and validity in social sciences. These threats are categorized into more than twenty specific categories, notice that these threats can apply to both internal validity and external validity (relevance).

Figure 5 Types of bias and error

Acquiescence response set ("yes saying")	Assumption/conceptual bias	Bias in handling outliers (unusual/"freak" data)
Design bias	Evaluation responses (giving responses expected from them)	Interviewer bias
Measurement decay	Mood bias	Non-response bias
Observer bias	Publication bias	Random measurement error

Reactive effect (Hawthorne effect)	Recall (memory) bias	Reporting bias
Response style bias	Sampling bias	Social desirability bias
Systematic error (due to selection bias in the sample, information bias or the presence of unknown variables skewing the results)	Total survey error	

(Bowling, A, 2002)

In a systematic review (in an EBR approach), the concept of validity is strongly associated with the study design of the different studies reviewed. Validity is based upon the assumption that certain study designs ensures validity to a higher degree than others. So a "Hierarchy of evidence" is used to assess validity of studies. This hierarchy is simply a list of study designs used to assess the effectiveness of interventions, ranked in order of decreasing internal validity (Petticrew & Roberts, 2006).

- Systematic reviews and meta-analysis
- Randomized controlled trials with definitive results
- Randomized controlled trials with non-definitive results
- Cohort studies
- Case-control studies
- Cross sectional studies
- Case reports

When conducting a systematic review you may say that the researcher has already established a "baseline" regarding the validity of the research in question by the selection of study designs to include in the review. It generates a "pool" of evidence where the probability of high internal validity and relevance are established in advance (high specificity). This is an important distinction; study designs with a high probability of high internal validity can still be poorly designed and conducted, jeopardizing validity. This problem has to be addressed during the review process and when the review protocol is developed (Wikipedia, 2010).

Relevance is a measure of how pertinent, connected, or applicable something is (Wikipedia, 2010). The term relevance equals to some degree the concept of external validity. I however, this study defines relevance as a measure of how a particular study do give us interesting results related to a general context. Relevance is with other words, not a scientific measure, but an educated opinion.

The term external validity is often replaced by the term transferability in qualitative research, but is essentially the same thing. The definition of external validity in research terminology is quite specific. External validity is when results or causal relationships can be generalized from one unique setting to other settings with other populations and conditions. In other words, are the results valid outside that particular study? This is a classical problem in research and there will inherently be a trade-off between internal and external validity. As a general rule, increased internal validity will decrease the external validity. But external validity is at the same time impossible to establish without internal validity. The real challenge is to find the right balance.

Figure 6 Degree of external validity
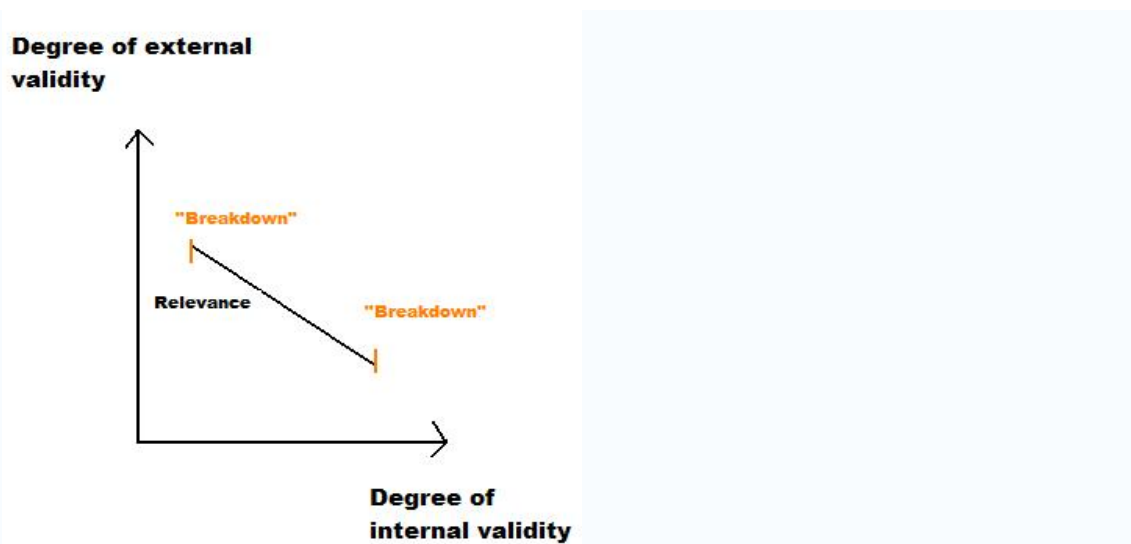
The degree of relevance decreases with increased internal validity, but just to a certain

point (Breakdown). There exist odd singularities where we observe absolute internal validity and universal truth. The relevance can just increase with decreased internal validity to a certain point (Breakdown). It is impossible to establish external validity without a degree of internal validity.

Researchers are now talking about "ecological validity", study designs that resembles the "real world" in a better way, addressing this particular problem (Bowling, 2002).We can talk about threats to external validity in the same way we can talk about threats to internal validity. Some common threats is described below:

Aptitude-Treatment-Interaction: The sample may have certain features that may interact with the independent variable, limiting generalizability. For example, inferences based on comparative psychotherapy studies often employ specific samples (e.g. volunteers, highly depressed, no comorbidity). If psychotherapy is found effective for these sample patients, will it also be effective for non-volunteers or the mildly depressed or patients with concurrent other disorders?

Situation: All situational specifics (e.g. treatment conditions, time, location, lighting, noise, treatment administration, investigator, timing, scope and extent of measurement, etc.) of a study potentially limit generalizability.

Pre-Test Effects: If cause-effect relationships can only be found when pre-tests are carried out, then this also limits the generality of the findings.

Post-Test Effects: If cause-effect relationships can only be found when post-tests are carried out, then this also limits the generality of the findings.

Reactivity (Placebo, Novelty, and Hawthorne Effects): If cause-effect relationships are found they might not be generalizable to other settings or situations if the effects found only occurred as an effect of studying the situation.

(Wikipedia, 2010)

A way of tackle the problem of external validity is to replicate the experiment or study design in other settings or "simply" examine a large enough sample across different studies in order to determine common/repeated results and effects. The systematic review and the meta-analysis represent this approach.

The classical experiment isolates on variable at a time, identifying their effect and impact and establishing causal (cause and effect) relationships. But the experiment is not always the proper research design, in particular regarding social sciences and indeed research on education, learning and learning processes. These domains are complex, habituated by people and with an infinite number of variables (discussed further in section 2.4, *Contextualisation and the complex nature of learning environments).* The systemic, complex nature of such environments makes generalizations difficult and external validity hard to establish. There are indeed ways of dealing with this problem. Application of multi variable analysis will handle a number of variables, not isolating one, but examine their different relations and strengths. Such research methods are often associated with a systemic approach.

2.4: Contextualisation and the complex nature of learning environments

This study ventures into the area of learning environments and its different constituent components. We have to understand the complexity of such environments to fully being able to investigate them.

"..all learning environments share a number of characteristics such as learners with their individual traits, habits, preferences and proclivities, instructions, learning materials, learning activities, social interactions and relations ,rules and regulations, norms and climates. In this sense, all learning environments —classrooms, museums, school field trips, afternoon clubs, soccer training sessions – are complex composites and thus need to be described, analyzed and studied as such."

(Elen & Clark, 2006)

2.4.1: Learning environments as systems

A short definition of a learning environment could be: "A physical, virtual or mental place we recognise as a place for learning and learning activities". This definition is valid in a formal and informal learning context, but does not apply to unformal contexts were learning is unintended but happening nevertheless. Unformal learning is outside the scope of this study. Learning environments have to be characterized as multifaceted and complex. We can also say that learning always appears in context, intended and unintended. The problem for researchers can be to sort out the intended from the unintended. Learning environments can be said to have three main attributes. Numerous components such as student characteristics, activities, rules and teacher-student interrelations etc.., comprise learning environments. This complexity is attribute number one. Attribute number two is that these components interact with each other. The third attribute is that these interactions and their consequences are constantly changing, making it impossible to describe a learning environment as a static, easily predictable entity (Salomon, 2006). Learning environments as complex systems cannot be explained fully by their individual parts, components or variables. They are in fact constantly interacting giving each other meaning and thus constantly changing. The variables are interacting reciprocally. This is a researcher's version of the old problem, what came first, the hen or the egg? Rather than a collection of variables that can be examined independently (*analytic approach*), we have to consider a learning environment as a composite of interdependent variables. These variables appear in a configuration that is structured in an organized manner, a system of interdependent variables that form specific patterns. Salomon talks about the distinction between "patterns of differences" and "differences of patterns" (Salomon 2006).

Figure 7 Difference of patterns
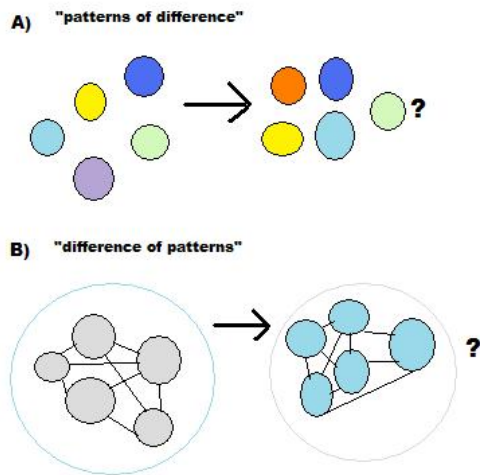
The normal way of researching is to look at differences between variables and the patterns of differences they create (A). But if we are considering learning environments to be complex systems of interdependent variables that form a pattern (configuration), we have to look at differences between whole patterns instead (B). This way of interpreting learning environments will inevitable change the way we assess validity. This pose a difference in the way we look upon learning environments, and the way we ought to conduct our research. We examine learning environments as systems and our approach can be described as *systemic*. The difference between the systemic approach and the analytic approach is illustrated by figure 8.

Figure 8 Analytic vs. Systemic

The analytic paradigm	The systemic paradigm
− You can break down complex situations and processes into their constituent components	− Situations and processes are viable entities and cannot be reduced to their components
− Single variables have meanings in and of themselves, independent of each other	− Variables come as "clouds of interrelated events", affecting and giving meanings to each other
− Hypothesis pertain to single variables	− Hypotheses pertain to whole Gestalts
− Behavior and learning are a function of what you can manipulate	− Behavior and learning are part of reciprocal interactions
− Manipulation of a variable leaves all others unchanged	− Changing one important variable is changing the whole configuration

(Elen & Clark, 2006)

It becomes clear that the inherent complexity of learning environments challenges the researcher in his quest for certified and exact knowledge about all its components' variables and their interrelations. His quest for causal relations between variables and a "feel" for its ever changing nature is no modest wish. It is probably no single research approach or methodology that can answer all these questions, this call for a multifaceted and diverse approach within a mixed array of research methods.

2.4.2: Introducing ICT in learning environments, ICT in context

All learning and all tools for delivering learning and facilitate learning activities and experiences are contextualized. Learning environments are complex systems and to predict the outcomes of an ICT intervention is hard indeed. If we want to assess outcomes for ICT interventions, their net effects and contributions, we will at a certain point compare these ICT interventions with "traditional" deliveries of learning facilitating activities. This is based on the assumption that the same learning outcomes can be compared across different technologies, media and methods. Underlying this

assumption is the idea that attainment of the same learning outcomes differ only in speed, depth, cost and sustainability across all media and technologies (G. Salomon & Ben-Zvi, 2006).

It seems that the only way of comparing ICT rich learning environments and more traditional ones is to use a common criterion for learning achievement and outcomes. Different learning environments scaffold different learning goals because they have different affordances incorporated. This will in turn make the comparison between the two by the same yardstick a flawed approach. This implies that different technologies, media and methods introduce certain "dynamics" of their own, properties and affordances that shape the learning environment in their own right thus making comparisons very difficult.

2.5: Social media, web2.0 and their "action potential"

ICT has to be perceived as a generic concept with abundant and diverse tools, technologies and different media operating in the digital domain. In order to handle this concept and to be able to assess this abundance we have to develop a coherent framework that can help us with the understanding and description of ICTs across all the individual properties. One of the most prominent properties of technology development in recent years is the abundant growth and development of web2.0 applications. The etymology of the concept web2.0 is interesting. Whereas the origin "web1.0" (my phrase) was about passive accommodation of knowledge, consume, web2.0 is about interaction, creation and collaboration. This has led many interested in learning to embrace these new technologies. It also fits in with a constructivist approach to learning, thus making it even more popular for learning purposes.

2.5.1: Web2.0

George Siemens and Peter Tittenberger use the phrase "the participative web" when referring to the web2.0 paradigm (Siemens, G. p.5 2009). The technology engages the

user actively. The user is not just a consumer, but in control of the technology. A more precise definition of the term is offered by Wikipedia:

*"The term "**Web 2.0**" (2004–present) is commonly associated with web applications that facilitate interactive information sharing, interoperability, user-centered design and collaboration on the World Wide Web. Examples of Web 2.0 include web-based communities, hosted services, web applications, social-networking sites, video-sharing sites, wikis, blogs, mashups, and folksonomies. A Web 2.0 site allows its users to interact with other users or to change website content, in contrast to non-interactive websites where users are limited to the passive viewing of information that is provided to them." {{216 Wikipedia}}*

There is little research done on the application of web2.0 for learning and teaching purposes. This is confirmed in a BECTA report from 2008 {{217 BECTA 2008}}. We know about the wide spread use of web2.0 applications (a simple Google search on web 2.0 yielded about 392 million hits), so it seems prudent to examine the use of these technologies further.

2.5.2: Teaching and learning activities with new media

George Siemens and Peter Tittenberger do not use the word ICT when they address the issues of technology impact on learning; they are using the term "new media" or just "media (Siemens & Tittenberger, 2009). The two terms are however interchangeable to a large extent. Their use of the term new media is associated with web2.0 applications to a large degree. Their starting point is to categorize different technologies (media) based on their different affordances. By affordances they mean how different media mediate, facilitate or scaffold particular learning activities (suitability). This is the technology's "action potential". So effective scaffolding of learning activities becomes an issue of selecting the right media. They also state that recent research in multimedia learning suggests that tools (media) is not just vehicles

of instruction delivery but do influence learning as they have certain "cognitively relevant characteristics" that influence the way the brain represents and process media. This is similar in some ways to what Salomon and Ben -Zvi states when they question the assumption that similar learning outcomes can be compared across different technologies, media and methods (G. Salomon & Ben-Zvi, 2006). "*Media and methods introduce certain "dynamics" of their own, properties and affordances that shape the learning environment in their own right.*" (ibid. section 2.4.2)

Siemens and Tittenberger sort different teaching and learning activities into four categories. Notice that they mention not just learning activities, but also teaching activities, further emphasizing this dimension and the role of the teacher. Note also that their perspective is aimed at the university level. Their categories are however easily adapted to other levels of education because the categories are quite general.

Dissemination – the provision of key material relating to a particular course. Through lectures, video, readings, audio recordings, and more recently, simulations, learners are exposed to the key components of a course. Whether handled in a traditional presentation model (like a lecture) or with more recent approaches (which begin to blend content presentation with learning activities, such as problem based learning)

Discussion – in a teaching context, involves direct learner to educator contact (learner to learner discussion is classified as a learning activity). This dialogue is important to move learners toward higher order thinking, or what corporations are increasingly calling "deep s marts" – a combination of experience and sustained participation in a particular field of study.

Discovery – directly involve the learners in "doing" – as individuals or as a group. The activities generally arise from the content within a course. The purpose of a learning activity is to assist learners in forming deeper understanding of subject matter. A biology lab, for example, involves the practical (and thereby, more meaningful) application of textbook theory.

Demonstration - is often perceived as separate from the act of teaching. However, assessment can provide valuable additional learning. Through the use of formative assessment techniques, learners can self-assess their understanding, and instructors can evaluate their teaching approach.

(Siemens & Tittenberger, 2009)

In the same instance they associate these activities with the prominent tools (media)

Figure 9 Prominent tools

	Mechanical age	Electronic age	Digital Age
Dissemination Presentation teacher to learners.	Course content provided by the teacher using the blackboard and the textbook. Delivered through lecturing and talking. Students take hand written notes. Prepared notes handed out (typewriters, stencils, gestetner, mimeograph).	Course content provided by the teacher using overhead projectors, slides, films and the textbook. Delivered through lecturing, talking and presentation. Students take hand written notes. Prepared notes handed out (electronic typewriters, Xerox).	Course content provided by the teacher using PowerPoint, web sites, cds, dvds, videos, computer applications, and the textbook. Delivered through lecturing, talking and presentations. Students take notes on laptops or PDAs. Prepared notes made available on the network.
Discussion Communication from teacher to learner and learner to learner.	Talk to teacher in class, or during office hours. Talk to students outside of class. Write a letter. Mechanical media limit the speed and geography limits the scope.	Telephones expand the speed (instantaneous) and remove geographic limits but introduce a mediated experience.	Learners have direct and instant access to a range of communication tools and applications from email, bulletin boards, chat, social networking, webcams, voip using a wide range of devices, mobiles, gaming platforms, computers. Geography no longer a barrier to communication. All communication mediated.
Discovery Discovery encompasses all those activities that learners engage in to expand their learning beyond the classroom. These may be scheduled activities such as experiments, labs, field trips, or independent investigation - research.	Additional course content available through the library. Science labs, experiments, and field trips are scheduled as part of courses.	Experiments use electronic equipment.	Learners have direct and instant access to a range of resources and learning activities that far exceeds what is found in the classroom: web searches, database searches, digital resources, virtual laboratories, simulations, virtual environments, augmented reality. Libraries become a secondary source of information as they are constrained by speed, scope and scale (although the Library 2.0 movement is trying to address this).

Demonstration	By learners in labs, tests	Increased use of technology in demonstrating competence (similar to instructor use of technology to teach)	Online labs (MIT), move to authentic assessment, eportfolios
Demonstration is most often seen in the form of formative and summative assessment. Assessment activities are designed to demonstrate mastery or understanding.			

(Siemens & Tittenberger, 2009)

2.5.3: The action potential of media

Now we have established main characteristics of learning and teaching activities and some media (tools) associated with them. Siemens and Tittenberger go one step further and suggest that media can be grouped by their affordances or "*action potential*". The action potential of a specific media, tool or technology can be described by six different affordances:

Access: The access of resources (filesharing options, e-mail, server access etc...)
Presence: As declaring a state of presence (online, offline, synchronous/asynchronous, augmenting presence (geotagging, gps, etc...))
Expression: Artistic, gestures (as in Second Life), profiling (as on most social networks)
Creation: Creation of new content and resources with blogs, wikis, websites or software.
Interaction: Forums, skype, e-mail, twitter, etc...
Aggregation: Aggregation of resources, relationships (social networking, social connections) through Facebook, iGoogle, NetVibes, LinkdIn, etc...

Note that media, tools and technology can inhibit several different affordances and that these affordances are not absolute, but have to be understood as being present to a varying degree. Siemens and Tittenberger are also talking about "emerging technologies" and that their perspective and choice of exemplifications are put into that context. They put emphasis on social software and social technology, constructivist learning and learning in networks as explored in Siemens ever developing idea of "connectivism" (Siemens, 2005). Siemens and Tittenberger also recognise learning environments as complex systems and that media has "cognitively

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relevant characteristics", which has a bearing on the way we operate and perceive with technology.

Technologies, media and tools have certain characteristics; these characteristics translate into particular affordances that mirror their action potential. The action potential of a certain technology can be understood as a function of affordances and their different strengths.

2.6: Research, effects in learning, what matters?

This study is examining a sizeable number of study designs that seeks to understand ICT and its effects on learning. To better understand the impact of ICTs we have to look at empirical evidence.

To put ICT in the right context it seems to be necessary to consider all variables that have an effect on achievement and learning outcomes. The most comprehensive study done in this field is perhaps John Hattie's analysis of effects in education (Hattie, 2009b). Hattie and his team systematized around 800 different Meta -studies on effects in learning. These studies covered 200 000 effects sizes, almost every method of innovation, approximately 180 000 individual studies and more than 200 million students worldwide. Student characteristics account for about 50% of the achievement factors. These are factors that cannot be changed or influenced in any substantial way. The second most important influence on achievement is the teacher, other influences only playing minor roles. In other words, we have to look at teaching practices if we really want to understand what matters regarding student achievement. An effect size (ES) of 1.0 would suggest that a whole class would get one better grade as a whole; the average grade for the whole class would be lifted one grade up, improving the rate of learning by 50% or advancing learners' achievement by one year. In other words, an effect size of 1.0 is really substantial.

Hattie has put up a table of effect sizes sorted from top to bottom after their effect sizes respectively. On top we find teachers feedback with an effect size of 1.13. If we

remove effect sizes related to student characteristics, we find these further down the list: Instructional quality (ES=1.0), Direct instruction (ES=0.82), Remediation/feedback (ES=0.65), Class environment (ES=0.56) and so forth (Teachers toolbox.co.uk, 2010). These are all teacher influenced effects. Hattie describes ICT through what he calls *Computer- assisted instruction.* This is a generic group of all sorts of technology effects. Hattie has calculated the different effect sizes, thus making it possible to compare them across studies. The data is based on more than 4500 different studies and almost 9000 different effects involving near 4 million students. Hattie calculated an average effect size of 0.37[1] across the different effects (Hattie, 2009b). Hattie defines this as an average effect size (John Hattie, 2008). In relation to the top scoring effect sizes, *Computer – assisted instruction* is of minor importance. It has been suggested that ICT is a maturing technology and that it needs time before it impacts, effect of computers will increase with the sophistication of the technology, but if we consider Hattie's results, there is no correlation between the effect sizes and the year if the study (Hattie, 2009b). In short, Hattie concludes that ICTs (*Computer – assisted instruction*) do not play an important role in students' learning achievement unless they are connected with other methods of instruction. Hattie found several conditions where ICT effects were enhanced by other teaching practices. -The use of computers was more effective when diverse teaching strategies were used

-The use of computers was more effective the teachers had received teacher pre-training on use of computers as a teaching and learning tool

-The use of computers was more effective when there were multiple opportunities for learning

-The use of computers was more effective when the student, not the teacher, is in "control" of learning

-The use of computers was more effective when peer learning is optimized

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[1] The table of effect sizes (Teachers toolbox.co.uk, 2010) operate with an effect size of 0.31.

These results have an important bearing on why we don't observe stronger effects by ICT on learning, and as I will discuss further, a bearing upon the way we conduct research and ultimately explaining my own findings.

Chapter 3: Methods and research process

A detailed account for the research process and the methods used is important in order to establish transparency, verifiability and a foundation for constructive criticism. This allows a third party to assess the research process and its robustness. The research questions are formulated in order to underpin this study's rationale

3.1: Research questions

Question 1: What kind of technology is evident in recent research into ICT and learning?

Question 2: Is it possible to identify a common feature among the studies in the review?

Question 3: Is this study confirming or contrasting other studies?

3.2: Choice of study design

The study is a systematic narrative review. However, mean effect sizes are calculated for 14 studies[2]. The study design used for the study was deemed as appropriate examining descriptive data within the sample, according to my research questions. The systematic review presents an approach that gives the researcher a tool for assessing a

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[2] Effect size calculations were conducted to investigate the effect size homogeneity across studies

large number of studies within a set topic and area of interest. The systematic review is a structured, specific and robust approach when compiling evidence or data, in this case published research studies.

3.3: A narrative synthesis

A narrative synthesis seeks to describe both heterogeneity and homogeneity within a data set or evidence pool descriptively. The key features, characteristics and properties of each study were summarized according to the "screening maps" (their categorizations and constructs) and translated to tabulated data and graphs (chapter 4). The screening maps are just the digital interface where the data was plotted. The methodology is accounted for in chapter 3 and the evidence/results discussed in chapter 4 and 5. The narrative synthesis of this review consists of chapter 3, 4 and 5 in the study

3.4: Development of tools, search criteria and procedures

Several digital tools were used in the review process. These tools relate at large to identifying, searching, compiling, categorisation, and aggregation and synthesizing data. No specific statistical tools were used. The procedures are describing the review process by search criteria and the inclusion and exclusion criteria. The tools and the procedures are described separately, but constitute what we normally would call a review protocol[3].

3.4.1: Tools for identifying data sources

The basic search was done largely through Google Scholar, identifying the different relevant journals.

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[3] See section 2.2

3.4.2 Tools for compiling studies

After identifying seventeen journals for sourcing the studies, each journal was screened for relevant studies. My compiling tool was called Second Brain™[4], (SB), an online filesharing and bookmarking tool, with an array of useful properties. I uploaded all the studies to SB, tagged the resources according to year, type of study and journal. This made it possible to create a simple searchable database for later use. Only the abstracts were uploaded, this meant that all relevant studies were kept in an online environment, no paper sources were used. SB is a free service.

3.4.3 Tools for categorisation

Questback[5] is an online service for making surveys and analysing data. Questback was set up with relevant categories and constructs accordingly. This created an online screening map (screening map 1) were all studies were filed and sorted. This process was repeated for the development of screening map 2. Screening map 3 was manually identifying data.

Figure 10 screening map 2

screening map 2, page 1   screening map 2, page 2

3.4.4: Tools for aggregation and synthesizing

Questback was also used for aggregation and synthesizing purposes. Questback has analyzing features incorporated in a separate module. Questback will sort; sum chosen categories, filtrate, compare and cross tabulate categories and variables. There are also opportunities for exporting datasets in several formats, including export for SPSS. All the graphics and statistics presented are aggregated in Questback.

Figure 11 Questback modules

Questback analysis module and export module
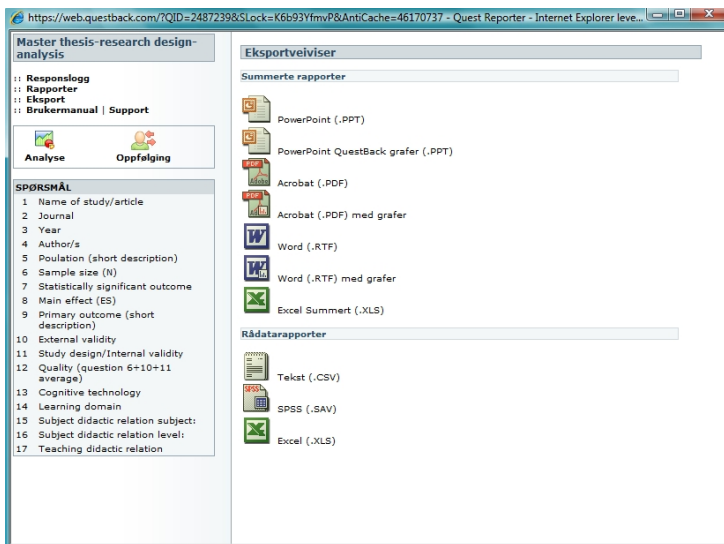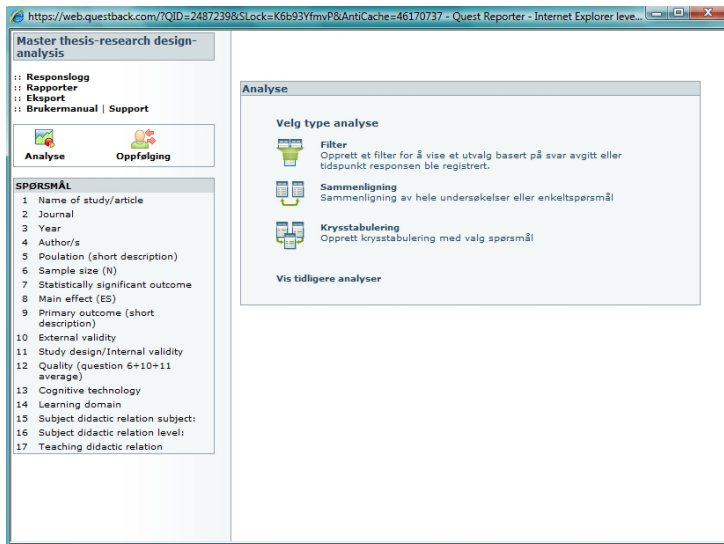
3.4.5: Search criteria procedures developed for the review process

The procedures and search criteria developed are an important part of the review because it directs the whole process. In a narrative review, the procedure is really the mainstay of the work done. I have visualized the review process with a flow chart in order to show the procedures "in work".

Figure 12 Flow chart review process
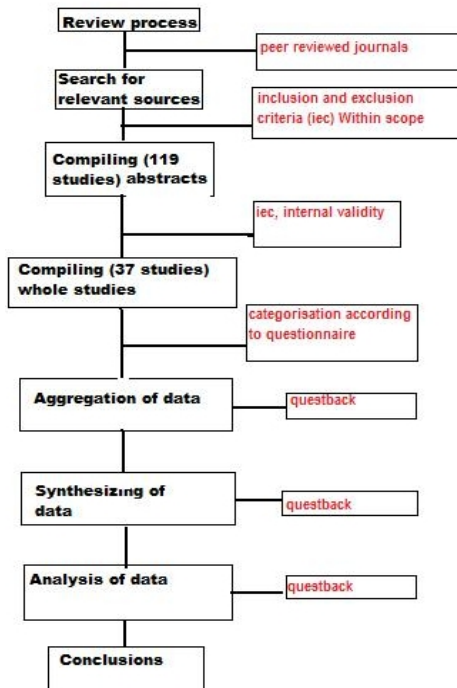
The figure above illustrates the process. Every stage has a procedure of its own; all procedures are an integral part of the review protocol.

Search criteria 1 (the search for data sources): *Peer to peer reviewed journals, free text search (search string: ICT, impact, effect, education...). English or Scandinavian language.*

Search criteria 1 was developed with the intention of sourcing high quality data from reputable sources. It was decided to only include peer to peer reviewed journals. This was done to ensure that the studies in advance had been screened by peer reviewers, thus ensuring an initial validity in sources. This initial search yielded thirteen different journals, all with English as publishing language. The search was done as an organic free text search in Google™ and Google Scholar™. The search yielded these journals:

- Instructional science
- Computers & Education
- British Journal of Educational Technology,
- Journal of Educational Computing Research
- Computers in Human Behavior

- Journal of Educational Computing Research,

- Australasian Journal of Educational Technology

- Education and Information Technologies

- Journal of Computer Assisted Learning

- Educational Technology Research and Development

- International Journal of Computer-Supported Collaborative Learning

- Review of Educational Research

- Journal of Science Education and Technology

(N=13)

Search criteria 2 (within scope of the review): Impact studies, effect studies, not attitudes, not beliefs, not implementation, not perceived interventions, ICT and learning, published between 2004 and 2009.

Search criteria 2 was developed with the intention of sourcing the individual research studies within each journal. This process involved the search of more than 600 individual studies. Only studies about impact and effect were considered. Studies about beliefs, attitudes or implementation were left out due to the reason of assessing the direct impact of ICT objectively, not through subjective opinion or through descriptive studies of implementation. Only studies made in the period between 2004 and 2009 were considered. This ensured to reduce the sheer number of studies to screen and to ensure relevance in relation to new theories, new technology and new practices. This screening yielded 119 individual studies[6]. Only abstracts were screened. The studies were compiled and tagged in Second Brain™.

Search criteria 3 (high internal validity): experiment (experimental design).

Search criteria 3 was developed to source only studies of high internal validity

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[6] appendix, cluster 1 of studies

according to the *"hierarchy of evidence"*[7], thus ensuring validity in the sample and integrity in the review. High internal validity is ensured at first hand by the way the research study is designed. This search was done on the basis of the Questback screening map 1 categorization[8]. This screening yielded 33 individual studies[9]. Of the thirteen journals represented at the start, now only nine was left with studies represented in the review.

- Instructional science
- Computers & Education
- British Journal of Educational Technology,
- Journal of Educational Computing Research
- Computers in Human Behavior
- Journal of Educational Computing Research,
- Education and Information Technologies
- Educational Technology Research and Development
- International Journal of Computer-Supported Collaborative Learning

(N=9)

The second phase of the review had a separate screening map (screening map 1) developed in Questback .The next part of the review was screening of 33 studies after search/screening criteria 3 had been applied.

The next phase of the review was to categorize all 33 studies according to screening map 2[10] (a Questback questionnaire). These findings are described in chapter 4, section 4.2, and include reading whole research studies and not just abstracts as in the first phase. The final categorization was done according to questionnaire 3 (done manually). These findings are described in chapter 4, section 4.3.

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[7] see section 2.2.3

[8] see section 3.4.3

[9] appendix, cluster 2 of studies

[10] see section 3.4.3

These three phases concluded the second part of the review (compiling, categorization and aggregation of evidence).

The last phase was to synthesize the evidence across all studies and different questionnaires. This was done by synthesizing tools provided in Questback (aggregation of evidence, summation of categories, development of graphs and charts and cross tabulation of categories). Note that cross tabulation of the data according to questionnaire 3 was not conducted due to manual data handling.

3.5: Development of constructs and screening categories

3.5.1: Constructs and screening categories for screening map 1

1. *Scale,* (sample size of article based on number of respondents/participants) - *small* – N= 25 or less, *medium* – N=25 to 100, *large* – N=100 or more.

2. *Country of origin* (Workplace of authors)

3. *Year published* (based on the year it was published online)

4. *Place submitted/published* (name of the journal)

5. *Research mode* (quantitative or qualitative or both)

6. *Effect* (*effect with, effect of or effect through*)

7. *Type of* research (experiment, case study, study, project evaluation, survey, meta-study, cohort study, action research, longitudinal study)

8. *Learning domain* (*Informal learning, Formal learning*) *Formal learning* is learning in a school/educational context (curriculum oriented/grade oriented/exam oriented/course oriented*...*) *Informal learning* is learning outside a 'controlled' school/educational environment, often driven by intrinsic motivation.

9. Learning arena (primary school, secondary school, university/college, distance learning, continued learning, vocational training)

10. Cognitive technology (mobile technology, virtual learning environment/LMS, serious games, games, virtual reality, web, web 2.0, simulation, computer mediated communication, digital tools, software tools, learning objects, modelling, concept mapping/mind maps, intelligent tutoring systems)

13. Subject context (none, mother tongue/language, foreign tongue/language, math, science, other)

15. Instructional regime: peer to peer learning, cscl, teacher centred, self instruction, and problem based learning, situated learning, other) It is possible to categorize the reports with more than one type of instructional regime, so the percentage number may exceed 100.

At large we are working with cognitive technologies in three separate ways. Categorization *6, Effect with technology* is the way we are working with a technology as a tool. We are able to do certain tasks with this tool, but are not able to do such tasks without the tool at a later point in time. *Effect of technology* is technology that leaves us with a 'cognitive residue'; our cognitive ability is altered, also when we are not working with that particular technology. *Effect through technology* is technology that changes whole concepts regarding a certain domain. These three constructs were incorporated in the framework for categorisation of studies (Perkins & Salomon, 2005). Categorization 12, the construct *Instructional regime* is an attempt on covering both the main ways of conducting teaching and ways of learning. A more appropriate name could have been *Learning regime.* The other constructs are quite easily identified and can be considered as descriptive. There are some irregularities between the article references and registrations on the variable *year publish*ed (Categorization 3) ; this is due to differences in articles published on paper and published online. There are also some irregularities regarding what sort of *cognitive technology* used (Categorization 10). Some abstracts were not sufficiently informative or unclear about what sort of technology used, others reported on technologies not incorporated in the screening

map 1. The same problem can be found in registration on other variables due to the same lack of information. This is causing small but noticeable sample errors.

3.5.2: Constructs and screening categories for screening map 2

1. *Name of study/article* (Journal and year)

2. *Author/s*

3. *Population* (short description)

4. *Sample size* (N)

5. *Main effect* (ES, if reported))

6. *Primary outcome* (short description)

7. *Study design/Internal validity* (Randomized experiment with control group, Experiment with control group, Quasi experiment, Non experimental design (case based, correlation studies, comparative *studies)*

8. *Cognitive technology* (Social media (communication and sharing tools), Specific learning objects, Specific learning software, Presentation tools (smartboards, smart desks, video...), Hypermedia (web, hypertext), Documentation tools/capture (cameras, mobile phones, recorders...), Documentation tools/storage/sorting/archiving (LMS, web based services), Generic applications (word, excel etc), Information tools (search engines, newsfeeds etc)

9. *Learning domain* (pre/primary education, lower secondary, upper secondary, higher education, other)

3.5.3: Constructs and screening categories for screening map 3

1. *What kind of technology is used?*

2. *Which category is attributed to the technology used?*

a. Access: The access of resources (filesharing options, e-mail, server access etc...)

b. *Presence*: As declaring a state of presence (online, offline, synchronous/asynchronous augmenting presence (geotagging, gps, etc...)

c. *Expression*: Artistic, gestures (as in Second Life), profiling (as on most social networks)

d. *Creation*: Creation of new content and resources with blogs, wikis, websites or software.

e. *Interaction*: Forums, skype, e-mail, twitter, etc...

f. *Aggregation*: Aggregation of resources, relationships (social networking, social connections) through Facebook, iGoogle, NetVibes, LinkedIn, etc...

3. *Does the technology support the learning activity based upon its affordances?*

Categorization 2 (*Which category do you attribute to the technology used?)* is based upon affordances[11] drawn up by Siemens and Tittenberger (Siemens & Tittenberger, 2009). Siemens and Tittenberger do not present a very specific definition of the six different affordances. There is a certain room for interpretation of the meaning of each affordance category, but they seem to have constructionalist, collaboration

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[11] see section 2.4.2

inclination. I have tried to adhere to Siemens' and Tittenberger's directions where "visible".

3.6 Effect size calculations

Measuring effect sizes was originally outside the scope of the review and the study. In order to examine their homogeneity within the sample and distribution by year, the effect size was calculated for fourteen additional studies. The studies were not randomly chosen, but selected on the grounds of feasibility. It was decided to include them in the study as a control feature. Feasibility was not any intended variable and can be said to equal randomization at best. This may introduce possible sample errors (not investigated). The results were incorporated in the study.

Chapter 4: Presentation of data

The data sets **screening map1** and **screening map 2** presented is created in Questback, data set of **screening map 3** is not digitally aggregated. Data from three separate screening maps are included, screening map 1, screening map 2 and screening map 3.

4.1: Data from "questionnaire" 1

4.1.1: Sum scores of questionnaire 1

Number of sampled studies are 119 (N=119) (There are a few small irregularities in the dataset due to missing original dataset, erased due to computer error and missing primary data in abstracts)

Table 1 scale

The category *scale* is sorting the studies into three different brackets in relation to the study's sample size. Bracket one: 1-25, Bracket two: 25-100, Bracket three: 100 or above. (sz=sample size)

Only 75 abstracts reported on number of respondents in that particular study. This is 63% of the total number of abstracts. (Scoring in %)

sz 1-25	sz 25-100	sz 100+
14,7%	36%	49,3%

(N=75)

Almost 50% of the studies had a sample size in excess of 100. If we add bracket two, (sz 25-100) we find that 85.3% of the studies are in the range of 25 to 100+ in sample size.

Table 2 country of origin

The category *country of origin* is sorting the studies according to where the author/author's country of origin. (If author's originates from different countries, the dominant country is scored). (Scoring in %)

34,5%	11,2%	10,3%	5,2%	4,3%	3,4%	2,6%	1,7%	0.9%	16,4%
US	UK	Taiwan	Germany Canada	The Netherlands	Australia	Finland	Norway Italy Turkey	Belgium Brazil New Zealand	others

(N=119)

Note the large US contribution of 34 % of the total number of studies in the sample. If

we add UK, Canada, Australia and New Zealand we find that 55.2 % of the studies are from English speaking areas. German and French speaking areas are present to a small degree. (No French studies in the sample). Also note that a relatively small country like Taiwan is a big contributor (10.3 %).

Table 3 year published

The category *year published* is sorting the studies according to publishing year .The articles were collected from a period of five years, 2004 – 2008. Please note there may be a significant delay between study execution and publishing. (Scoring in %)

2004	2005	2006	2007	2008
8,8%	10,5%	13,2%	33,3%	34,2%

(N=119)

Note the distributions of studies on the measure of year, 67.5% of the studies are from 2007 and 2008.

The category *place submitted*: Missing due to registration error

(N= no value)

Table 4 research mode

The category *research mode* is sorting the studies according to three types of research mode (qualitative, quantitative, combination) (Scoring in %)

qualitative	quantitative	combination
17,9%	61,9%	20,2%

(N=84)

Quantitative study designs are prominent with a score of 61.9%. If we add the number of studies with a combination of both quantitative and qualitative study designs we end up with a score of 81.1%. The percentage for combined studies and studies with only qualitative study designs is 38.1%

Table 5 effects

The category *effects* is sorting on three different types of effects[12] relating to Perkin's and Salomos' thoughts about how we use and assimilate cognitive technology (Perkins & Salomon, 2005).), *Effect of technology, Effect with technology, Effect through technology.* The percentage number exceeds 100; this is due to abstracts representing more than one type of effect. 12, 3% of the cases represent both *Effect with technology* and *Effect of technology.* (Scoring in %)

Effect of technology	*Effect with technology*	*Effect through technology*
15%	97,3%	0%

(N=113)

Note 97.3% of the studies observe effect with technology.

Table 6 type of research

The category *type of research* is sorting the studies in seven different types of research. *Study, Experiment, Case study, Survey, Meta-Study, Longitudinal Study, Cohort Study, Project Evaluation, Action research.* The total percentage number exceeds 100 because research abstracts can be categorised with more than one type of research. (Scoring in %)

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[12] See section theory 3.5.1 on *the category effect*

Study	Experiment	Case Study	Survey	Meta-study	Longitudinal study	Cohort study	Project evaluation	Action research
58,6%	42,2%	12,1%	5,2%	3,4%	2.6%	1,7%	0%	0%

(N=113)

The category *Study* is the biggest category with 58.6%. *Experiment* scores 42.2%. The third biggest category is *Case Study* with 12.1%. The other categories are quite small in comparison.

Table 7 learning domain

The category *learning domain* is sorting the studies in two different learning domains. *Formal learning, Informal learning.* (Scoring in %)

Formal learning	Informal learning
96,4%	3,6%

(N=112)

Note the very small percentage of the category 3.6%. This result does indicate that large domains of learning are not included in research on ICT and learning.

Table 8 learning arena

The category *learning arena* is sorting the studies in six different arenas of learning where the research took place. *Primary school, Secondary school, University/college, Distance learning, Continued learning, Vocational training.* (Scoring in %)

Primary	Secondary	University/college	Distance	Continued	Vocational

school	school			learning	learning	training
20,2%	22,3%	51,1%	4,3%	1,1%	1,1%	

(N=94)

Note that a majority of the studies are situated in a University/college context. Both *Primary school* and *Secondary school* are of equal size, 20.2% and 22.3% respectively. This is again leaving out large areas of learning.

Table 9 cognitive technology

The category *cognitive technology* is sorting the studies in seventeen different technologies. More than one technology can be attributed to each study. *Mobile technology, Virtual learning environments (LMS), Serious games, Games, Virtual reality, Web, Web2.0, Simulation, Social platforms, Computer mediated communication, Digital tools* (cameras, recorders, audio/video), *Software tools, Digital learning objects, Modelling, Mind maps/concept mapping, Intelligent tutoring systems.* (Scoring in %)

Mobile technology	Virtual learning environments (LMS)	Serious games	Games	Virtual reality	Web	Web2.0	Simulation	Social platforms
2,7%	15,3%	3,6%	9,9%	2,7%	24,3%	2,7%	8,1%	0%

Computer mediated communication	Digital tools (cameras, recorders, audio/video)	Software tools	Digital learning objects	Modelling	Mind maps/concept mapping	Intelligent tutoring systems		
13,5%	3,6%	26,1%	0,9%	8,1%	8,1%	5,4%		

(N=111)

Web scores 24.3%, the second largest category is *Software tools* with 26.1% The other scores are spread quite evenly. Note that the category *Web2.0* only scores 2.7%

Table 10 subject context

The category *subject context* is sorting the studies in six different subject contexts. (Whether the study describes the intervention or activity in a subject context) *Mother tongue/language context, Math subject context, Foreign tongue/language context, Science subject context, Other subject* contexts, *No subject context.* (Scoring in %)

Mother tongue/language context	Math subject context	Foreign tongue/language context	Science subject context	Other subject contexts	No subject context
5,1%	10,3%	3,4%	17,9%	42,7%	20,5%

(N=117)

The biggest category within the sample is *Other subject contexts* with a score of 42.7%. Note that it was not possible to determine any subject context for 20.5% of the studies.

Table 11 instructional regime

The category *instructional regime* is sorting the studies according to instructional practices. *Peer to peer learning, cscl, teacher centred, self instruction, problem based learning, situated learning, other.*

Peer to peer learning	cscl	teacher centred	self instruction	problem based learning	situated learning	other
24,2%	42,4%	15,2%	33,3%	12,1%	0%	15,2%

 Peer to peer learning was represented in 24, 2% of the abstracts, *cscl* was represented in 42, 4%, *teacher centred* was 15, 2%, *self instruction* was 33, 3%, *problem based learning* was 12, 1%, *situated learning* was 0% and *other* was 15, 2%. Note the large category of *cscl (42.4%)* Also note the sample score of only 33. (N=33).

4.2: Data from screening map 2

The data is treated descriptively, correlations are not calculated. Number of sampled studies are 33 (N=33)

Table 12: Studies distributed by year

The measure tells us which year the studies were published
(scored by percentage and number)

Navn	Prosent
2004	6,1 %
2005	6,1 %
2006	18,2 %
2007	18,2 %
2008	39,4 %
2009	12,1 %
N	33

Navn	Antall
2004	2
2005	2
2006	6
2007	6
2008	13
2009	4
N	33

The distribution of studies by publishing year reveals that a majority of the studies are from the last three years (2007, 2008 and 2009). This is interesting when we look upon the scoring for *cognitive technology, table 6.*

(N=33)

Table 13: Sample size of studies

This is a measure of the sample size of each individual study scored from low to high sample sizes

15	15	23	25	30	32	39	40	40	44	46	50	50	62	64	74	75
87	88	92	111	113	116	121	122	132	132	138	147	161	185	192	220	

Mean= 87, 4 Median=74

(N=33)

Table14: Return of significant outcomes

This is a measure of studies observing significant outcomes from the interventions

Navn	Prosent
yes	90,9 %
no	9,1 %
N	33

Navn	Antall
yes	30
no	3
N	33

This category just observes if the study reports of significant outcomes or not. No assessment of the degree of significance took place.

(N=33)

Table 15a: Effect sizes

This is a measure of the effect size (ES) of fourteen studies in the sample[13]

0.009	0.03	0.08	0.12	0.138	0.20	0.215	0.245	0.25	0.365	0.485	0.52	0.53	0.64

Mean ES= 0.27 Low ES=0.009 High ES=0.64

These are interesting results, there is no calculations of correlations against other variables. But, the effect sizes are quite small, and a mean of ES=0.27 confirms the results from John Hattie's study.[14]

(N=14)

Table 15b Effect sizes distributed by year

The same measure as *Effect sizes (Table 4a),* distributed over by the year the study was published.

				0.64	
				0.53	
0.485			0.365	0.52	
	0.138		0.245	0.20	0.25
0.12		0.03	0.215	0.009	0.08
2004	**2005**	**2006**	**2007**	**2008**	**2009**

Note that there is an uneven distribution of effect sizes (ES). There seem to be a connection with the number of effect sizes for 2008 and the number of studies published that year (Table 12).

(N=14)

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[13] See list of studies/effect sizes

[14] See chapter 5 for further discussion.

Table 16: Study design

This category sorts the studies according to different study designs

Navn	Prosent
Randomized experiment with control group	21,2 %
Experiement with control group	30,3 %
Quasi experiment	48,5 %
Non experimental design (case based, corrolation studies, comparative studies…)	0,0 %
N	33

Navn	Antall
Randomized experiment with control group	7
Experiement with control group	10
Quasi experiment	16
Non experimental design (case based, corrolation studies, comparative studies…)	0
N	33

The largest category is *Quasi experiment* with 48.5%. This suggest that *search criteria 3*[15] was implemented successfully.

(N=33)

Table 17: Cognitive technology

This category sorts the studies according to the technology used for the intervention.

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[15] See section 3.4.5 for search criteria developed

Navn	Prosent
Social media (communication and sharing tools)	9,4 %
Specific learning objects	3,1 %
Specific learning software	56,3 %
Presentation tools (smartboards, smartdesks, video...)	12,5 %
Hypermedia (web, hypertext)	12,5 %
Documentation tools/capture (cameras, mobilephones, recorders...)	0,0 %
Documentation tools/storage/sorting/archiving (LMS, web based services)	3,1 %
Generic applications (word, excel etc)	3,1 %
Information tools (search engines, newsfeeds etc)	0,0 %
N	32

Navn	Antall
Social media (communication and sharing tools)	3
Specific learning objects	1
Specific learning software	18
Presentation tools (smartboards, smartdesks, video...)	4
Hypermedia (web, hypertext)	4
Documentation tools/capture (cameras, mobilephones, recorders...)	0
Documentation tools/storage/sorting/archiving (LMS, web based services)	1
Generic applications (word, excel etc)	1
Information tools (search engines, newsfeeds etc)	0
N	32

(N=32)

Notice the high percentage of *Specific learning software* with 56, 3%. The low percentage of *Social media* is also interesting to observe, particularly when we acknowledge the impact of social media/web 2.0 recent years[16].

Table 18: Learning domain

This category sorts the studies according to different level of education

Navn	Prosent
pre/primary education	18,8 %
lower secondary	18,8 %
upper secondary	9,4 %
higher education	50,0 %
other	3,1 %
N	32

Navn	Antall
pre/primary education	6
lower secondary	6
upper secondary	3
higher education	16
other	1
N	32

Higher education dominates the category *Learning domain* (50%), this can probably be explained by the fact that research often is initiated at university/college level and that it is natural to conduct research in the same settings. This may introduce a bias in the sample. There is interesting to see that the category *other* represents just 3,1 % of the sample, this suggest that arenas of learning are excluded, like vocational training, adult learning, learning at the workplace, trade specific training and informal learning.

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[16] See section 2.4

(N=32)

4.3: Data from screening map 3

Table 19: Correspondences between technology and affordances

The table shows the relation between Siemens' and Tittenberg's affordance model[17] and the technology used in the individual studies.

2		no
3	Generating mindmaps	interaction
4	Concordancer	no
5	Multimedia (ie, text, colour, auditory–verbal, and animation)	no
6	Videoconference shared workspace	Interaction,expression
7	Problem-based video instruction	no
8	Computerized testing system	no
9	Concept map-based information system	Creation,access
10	Online discussion	interaction
11	Computer based comprehension aids	no
12	Online discussion, wiki	Creation,interaction
13	Gaming	no
14	Gaming	no
15	Podcasting	no
16	Collaborative conceptmaps	interaction
17	Simulations	no
18	Web based bulletin board	interaction
19	Web based electronic lab	no
20	We based learningevironment	Access, interaction
21	Electronic question promts	no
22	Digital learning system	no

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[17] see section 2.4

23	Virtual learning evironment, immersion	no
24	Computer simulation	no
25	Videoconferencing	interaction
26	Cmc	interaction
27	Computer visualisations	no
28	Gaming	interaction
29	-	no
30	Gaming	no
31	Gaming	no
32	Learning programme	no

The data offered are not valid as a mean for understanding technologies as such. The different affordances or action potentials are not generally applicable. They are describing affordances, but at a more general level. That makes the affordance model hard to use as an analytic tool for different media. They do however; offer an interesting connection between technology and activity, making them interesting in learning and teaching perspectives.

Chapter 5: Conclusions, implications and suggestions

This study contains a lot if data, not all of equal interest. Some of the results have more importance than others; these will be discussed more in depth. I have

formulated three different research questions; they are all addressed in the following sections of chapter five.

Question 1: What kind of technology is evident in recent research into ICT and learning?

Question 2: Is it possible to identify a common feature among the studies in the review?

Question 3: Is this study confirming or contrasting other studies?

5.1: Discussion of data

A descriptive study does not go in depth, other research practises are far more suited. The systemic review give such studies more power, grounded in a rigorous and structured approach to data gathering. A descriptive study is an appropriate way of examining a domain on the "surface" giving you the "bird's eye" view.

5.1.1: Data according to screening map 1

The numbers of included studies are 119 and give the data some power. The study is observing quite healthy sample sizes among the studies, this suggest well planned and robust study designs. The first really interesting data is the "English speaking" dominance among the studies. Several explanations may be offered, but could be that the journals do publish in English, making the potential non English speaking submitter apprehensive. Even if English is a working language among researchers, we do know that many are not very fluent, verbally and in writing. This seems to exclude larger groups. The most prominent feature was the lack of French study designs in the sample. This should be taken seriously; we are potentially missing out on good research. Taiwan is the third biggest contributor in the sample, suggesting that the

Taiwanese are using resources in their educational system, encouraging research.

About two thirds of the studies are published in 2007 and 2008, making sure that the data is recent and more valid. The studies seem to be representative for the situation now. Quantitative study designs are the more prevalent and if you include the studies that combine both quantitative and qualitative measures, the percentage reaches 81.1%. This is probably due to the search criteria of the study, asking for studies about effects of ICT on learning. Such effects are more easily identified and verified with quantitative measures.

The share of studies that were outside the formal educational system was 3.6%, a tiny amount when you know how large group this represents. This picture is augmented by the next measure, *learning arena,* where categories as *Distance learning, Continued learning* and *Vocational learning,* have a share of just 6.4% of the studies in the sample. The *University/college* category is left with 51.1% of the studies. The reason can be that the *University/college* category represents institutions that by tradition and stature, and indeed by law, does research. It is however a potential problem if populations, subject matter and researchers (in future studies), are representing just one sector in the educational system.

The measure *cognitive technologies* scores web2.0/social media applications with just 2.7%. This is noticeable when we know the hype surrounding this concept in recent years. The answer may be that these technologies are to be considered "cutting edge" and not yet "mainstreamed". If we look upon research into these matters, there is enough to look at the work done by Media Zoo at Leicester University (University of Leicester, 2007). The group, led by Gilly Salmon are researching several web2.0/social media applications, (among them Second Life), and they are not deemed mainstream by the researchers (for learning purposes). The two largest categories within the measure are *Web* with 24.3% and *Software tools* with 26.1%. They probably represent mature technologies, now mainstreamed for learning purposes.

5.1.2: Data according to screening map 2

(N=33)

The distribution of studies by year shows us much the same as in the larger sample of screening map 1. There is consistency across the two studies on this point. The sample of screening map2 is further being augmented with studies from 2009. The sample represents recent research.

None of the studies were non experimental. This suggests that *search criteria 3*[18] were implemented successfully. Randomized experiments with control group scored 21.2%. Experiment with control group scored 30.3% and quasi experiment scored 48.5%. The amount of studies scoring in the quasi experiment category being quite higher than the two other groups. This may be a sign of how difficult there is to run randomized experiments in a pedagogical setting.

The use of technology follows much the same pattern as in screening map 1. There is a certain consistency between the two samples (of course, 33 studies represent the same data even if the typologies are different between the two samples). The same pattern is to be observed on the use of web2.0 technologies as in screening map 1.

The same pattern reoccurs regarding where the research is done, the university and college sector is again, represented with 50% of the studies.The study calculated the effect sizes from fourteen randomly selected studies within this study's sample and this resulted in a mean effect size of just 0.27[19], somewhat lower than the mean from Hattie's study (ES=0.37) (Hattie, J. 2009).These results fit in with the results gathered by Hattie and confirms these results, thus heightening the external validity of that study in my opinion. Such effect sizes are according to Hattie small to average and

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[18] See section 3.4.5 for search criteria developed

[19] See section 4.2 Table 15a,b

reinforce the picture of a limited effect by ICT interventions on learning. This presents newer data than Hattie's, further confirming his findings.

5.1.2: Data according to screening map 3

See section 4.3, table 19 for comments

5.2: A bigger picture, ICT in context

According to Hattie, there are other methods of teaching that represents higher effect sizes, several of them directly connected with teaching practices, regardless of technology.

As we already have established, *computer –assisted instruction* is only averaging an effect size of 0.37[20]. The real problem is to be able to cancel out all the background variables (e.g. social economic status, cognitive characteristics, learning abilities etc…) introduced in the sample. If we could introduce a fully randomized sample in both the experimental group and the control group, the background variables would be cancelled out all together and we would be able to measure the method of instruction alone. This is difficult to accomplish in pedagogical research, thus making it hard to pin down the different variables that make an effect on achievement or learning outcomes. This problem can be solved by a systemic approach where the researcher examines a cluster of variables and determines their different interrelations and strengths. The complexity of a learning environment or a learning process introduce a

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[20] See section 2.6

whole lot of effects, it is a problem if greater effects in a study are not accounted for, this may mask the smaller ones (e.g. *computer-assisted instruction).* If we try to measure the effect of ICTs in a genuine learning environment, the greater effect sizes will probably be dominant and mask the smaller ones. Picture a fish tank at the aquarium, the sharks and ray fish are spotted immediately, the smaller fish are only to be seen after a much more careful look, up close. The sharks and the ray fish will be the greater effects in this metaphor, the small fishes the lesser (and the sharks tend to eat the small fish as well…). It seems to be that Hattie's results strengthens the view of ICTs as mere tools and those they provide little effect on learning if not connected to sound and mindful teaching practices. We can't expect great effects of ICT if they are disconnected, out of context or in some way not scaffolding already good teaching practices.

We meet a real challenge regarding researching learning and learning processes, we tend to run into validity problems with an experimental approach, but also problems determining the effects of the ICT interventions because the greater effects "wipes out" the smaller ones. It seems that expert opinion is observing the same problem and tries to combat this problem by suggesting a change in research practices.

5.3: Expert opinion

An increasing number of experts are referring the evidence brought forward by Hattie, similar studies and other research. These results seem to have an impact on the way we perceive ICT and also on governing policies. The European Commission has initiated a project called STEPS 2009 (STEPS Project, 2009). This project looks into the impact of ICT in primary education. As Godelieve van den Brande from the EU Commission stated, they are now looking into the teaching practices with ICT, emphasising the role of the teacher when she cited the preliminary findings from the STEPS project The STEPS project goes into a broader EU perspective as well, looking into all levels of education.

A recent EU workshop held by the European Commission/IPSC (Joint Research Centre), Centre for Research on Lifelong Learning (CRELL), and OECD/CERI (Centre for Educational Research and Innovation) was put together discussing the problem policy makers have in relation to the lack of clear information on the impact and effects of ICTs on learning. They state that there is a lack of comprehensive studies of the complex interactions between ICT interventions and other school interventions and characteristics. They device a systemic approach, identifying ICT practices and their effects at all the different levels of learning and education (OECD (CERI), European Commission (IPSC), CRELL, 2009). In other words, they realise that current research does not give the answers they need and that the research has to be systemic to cover the complexity of learning processes, thus implicitly criticising research to be to narrow in its scope. A systemic approach is associated with different types of analysis where multiple variables are examined in order to define and describe their different interrelations quantitatively. This questions in my opinion the relevance of traditional high internal validity research or the experimental approach to research if you like. Further, this concern is voiced by the different participants of the workshop group, most noticeably perhaps, Robert Kozma. He states in his work paper (addressing 21th century skills and competencies) that these skills and competencies has to be defined in measurable ways, classroom practices and environments has to be connected to assessments to increase scalability and methodological issues has to address rigor and validity. He is questioning validity, relevance and the lack of connections to skills/competencies in research. Further Francesco Pedró and Benât Bilbao-Osario from OECD state that little empirical evidence about the final benefits associated with ICT more broadly are to be found. They also point to the inconclusive evidence about ICT and performance in research (OECD Centre for Educational Research and Innovation (CERI), Centre for Research on Lifelong Learning (CRELL), & European Commission - Joint Research Centre (IPSC), 2009). Roni Aviram from Ben-Gurion University says that it is hard to measure higher achievement from ICT beyond specific contexts while showing meaningful sustainable increase in performance at the same time. He also points to the lack of longitudinal evaluations regarding sustainability and

transferability of ICT interventions in learning. Aviram also discusses another important problem; implementation of ICT has not led to change of teaching and learning processes according to desired methodologies (OECD Centre for Educational Research and Innovation (CERI) et al., 2009). The teacher teaches as he always has taught, regardless of the technology in use. Again, it seems to be a consensus regarding lack of evidence and that a systemic and multifaceted approach to evidence gathering is needed.

A rather bleak picture of the current impact and effectiveness of ICTs on learning is presented.

5.4: Final conclusions, suggestions

This study convey certain common features among the studies in this study, most noticeably being low effect sizes, the Anglo-American dominance, the number of studies within a university and college context and lastly, how big arenas for learning is not being exploited by research. The absence of web2.0 was a bit surprising, but a possible explanation is offered. My report did not contrast other research, but confirmed the Hattie's study, this is significant. Hattie's findings are still valid, confirmed by newer data.

The findings support the current view of educational research generally and research into effects of ICTs specifically. Research into learning with ICTs has to be multifaceted and diverse in order to uncover the evidence needed. Much speaks for a more coherent approach where a conceptual framework and proper indicators for the assessment of ICT effects are developed. Experimental study designs are not inappropriate, but have to be augmented and complemented by other research approaches in order to give us a more coherent picture of the true potential and effects of ICTs on learning. Different research questions demand different research approaches. Evaluating processes are often best described qualitatively; deciding on the best method would often require a quantitative or experimental approach.

The complexity of learning environments has to be taken into consideration. ICTs have to be associated with proper teaching practices and their different strengths and affordances considered accordingly. This challenges the didactic competence of the teacher and the way we train our teachers. The wish for scientific "fact" by important stakeholders has put a demand on evidence based research and quantitative research. In a situation where the effects of ICT are not yet fully understood or investigated, such research is certainly asked for. If we do have a situation where the research done on ICT effects is without great relevance in parts, we do have to question our research methods. This study has just touched upon a very small part of a complex reality and tried to explain some reasons why we have trouble finding solid and grounded evidence. Our research methods clearly have to change and we probably have to change the way we perceive ICTs in learning. A systemic approach seems prudent and should be augmented by diverse research approaches in order to provide us with solid evidence.

Drammen 04.03.2010

Jakob Sletten

List of studies/effect sizes

Name of study		Mean effect size
Choi, H. J., & Johnson, S. D. (2007). The effect of problem-based video instruction on learner satisfaction, comprehension and retention in college courses. *British Journal of*		0.245

Educational Technology, 38(5), 885-895.		
Choi, S., & Clark, R. E. (2006). Cognitive and affective benefits of an animated pedagogical agent for learning english as a second language. *Journal of Educational Computing Research, 34*(4), 441-466.		0.03
Daud, N. M., & Husin, Z. (2004). Developing critical thinking skills in computer-aided extended reading classes. *British Journal of Educational Technology, 35*(4), 477-487.		0.485
Franzke, M., Kintsch, E., Caccamise, D., Johnson, N., & Dooley, S. (2005). Summary street®: Computer support for comprehension and writing. *Journal of Educational Computing Research, 33*(1), 53-80.		0.138
Graff, M., Mayer, P., & Lebens, M. (2008). Evaluating a web based intelligent tutoring system for mathematics at german lower secondary schools. *Education and Information Technologies, 13*(3), 221-230.		0.52
Grimshaw, S., Dungworth, N., McKnight, C., & Morris, A. (2007). Electronic books: Children's reading and comprehension. *British Journal of Educational Technology, 38*(4), 583-599.		0.215

Papastergiou, M. (2009). Digital game-based learning in high school computer science education: Impact on educational effectiveness and student motivation. *Computers & Education, 52*(1), 1-12.		0.25
Park, J., & Choi, B. C. (2008). Higher retention after a new take-home computerised test. *British Journal of Educational Technology, 39*(3), 538-547.		0.20
Shavalier, M. (2004). The effects of CAD-like software on the spatial ability of middle school students. *Journal of Educational Computing Research, 31*(1), 37-49.		0.12
Holzinger, A., Kickmeier-Rust, M. D., Wassertheurer, S., & Hessinger, M. (2008). Learning performance with interactive simulations in medical education: Lessons learned from results of learning complex physiological models with the HAEMOdynamics SIMulator. *Computers & Education,*		0.64
Demetriadis, S. N., Papadopoulos, P. M., Stamelos, I. G., & Fischer, F. (2007). The effect of scaffolding students' context-generating cognitive activity in technology-enhanced case-based learning. *Computers & Education,*		0.365

Limniou, M., Roberts, D., & Papadopoulos, N. (2008). Full immersive virtual environment CAVETM in chemistry education. *Computers & Education, 51*(2), 584-593.		0.53
Ploetzner, R., Lippitsch, S., Galmbacher, M., Heuer, D., & Scherrer, S. (2009). Students'difficulties in learning from dynamic visualisations and how they may be overcome. *Computers in Human Behavior, 25*(1), 56-65.		0.08
Vernadakis, N., Zetou, E., Tsitskari, E., Giannousi, M., & Kioumourtzoglou, E. (2008). Student attitude and learning outcomes of multimedia computer-assisted versus traditional instruction in basketball. *Education and Information Technologies, 13*(3), 167-183.		0.009

Screening map 1

1. Scale

2. Country of origin

3. Year published

4. Place submitted/published (name of the journal)

5. Research mode (quantitative or qualitative or both)

6. Effect (*effect with, effect of or effect through*)

7. Type of research (experiment, case study, study, project evaluation, survey, meta-study, cohort study, action research, longitudinal study)

8. Learning domain (*Informal learning, Formal learning*)

9. Learning arena (primary school, secondary school, university/college, distance learning, continued learning)

10. Cognitive technology (mobile technology, virtual learning environment/LMS, serious games, games, virtual reality, web, web 2.0, simulation, computer mediated communication, digital tools, software tools, learning objects, modelling, concept mapping/mind maps, intelligent tutoring systems)

12. Instructional regime (*cscl, drill, traditional teacher centred, self instruction, problem based learning, situated learning)*

13. Recognisable effects (*minimum, medium, maximum*).

14. Subject context (*none, mother tongue/language, foreign tongue/language, math, science, other)*

15. Teacher involvement (yes/no: varied teaching methods, student active learning, clear learning goals, detailed and good planning, visible leadership, good social relations, peer to peer learning)

16. Subject knowledge (course, bachelor degree, master degree, above, none).

17. Instructional regime: (*yes/no: peer to peer learning, cscl, teacher centred, self instruction, problem based learning, situated learning, other)*

(The electronic version was deleted by mistake)

Screening map 2

Master thesis-research design- analysis

sletten@nade-nf1

	2487239		17		0		

Name of study/article

[   ]

Journal

[   ]

Year

☐ 2004

☐ 2005

☐ 2006

☐ 2007

☐ 2008

☐ 2009

Author/s

[   ]

Poulation (short description)

[   ]

Sample size (N)

[   ]

Statistically significant outcome

☐ yes

☐ no

Main effect (ES)

[   ]

Primary outcome (short description)

[   ]

External validity

☐ 1 ☐ 2 ☐ 3

Study design/Internal validity

☐ Randomized experiment with control group

☐ Experiement with control group

☐ Quasi experiment

☐ Non experimental design (case based, corrolation studies, comparative studies…)

Quality (question 6+10+11 average)

[   ]

Cognitive technology

☐ Social media (communication and sharing tools)

☐ Specific learning objects

☐ Specific learning software

☐ Presentation tools (smartboards, smartdesks,video…)

☐ Hypermedia (web, hypertext)

☐ Documentation tools/capture (cameras, mobilephones, recorders…)

☐ Documentation tools/storage/sorting/archiving (LMS, web based services)

☐ Generic applications (word, excel etc)

☐ Information tools (search engines, newsfeeds etc)

Learning domain

☐ pre/primary education

☐ lower secondary

☐ upper secondary

☐ higher education

☐ other

Subject didactic relation subject:

☐ elementary

☐ peripheral

☐ open

Subject didactic relation level:

☐ fundamental

☐ peripheral

☐ open

Teaching didactic relation

☐ exemplary

☐ non exemplary

☐ open

100 % completed

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Appendix

Cluster 1 of studies (119):

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