
Teaching in Technology-Rich Classrooms: is there a gap between teachers' intentions and ICT practices?

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ABSTRACT The Norwegian school system gives a high priority to information and communication technology (ICT), and its ICT density is high, with one laptop per student considered desirable and being nearly accomplished. This study seeks to find the reasons for aspects of Norwegian teachers' pedagogical behaviour and choices by focusing on their thoughts and practices in technology-rich classrooms and by analysing how they explain them. It aims to enhance our understanding of how teachers in leading-edge schools appreciate the possibilities of a technology-rich environment, using theories about teachers' technological pedagogical content knowledge as a framework. The informants in this study had worked as teachers in upper secondary schools for at least five years and were categorised as digitally competent. Interviews conducted early in the study showed them struggling to explain their ICT use because teaching is a complex activity and ICT can not be isolated from it. To increase the validity of the study it was therefore necessary to employ a more composite research method, collecting data from the researchers' and the schools' reports and from development work with ICT, interviews with teachers, videotaped lessons, videotaped discussions with teachers after lessons, and videotaped discussions involving teachers sharing their reflections with colleagues. The study shows that if teachers do not feel comfortable with changes, teaching practices stay the same. At the same time these teachers have developed, and have continued to develop, a digital pedagogical content knowledge which seems to be necessary in the digitised school of today.

Introduction

All curricula in Norway since the Second World War have put a strong emphasis on individual learners and have advocated such progressive ideas as subject integration and active student learning. Individualisation and adapted education, understood as pedagogic differentiation, has been a strong theme in all these curricula. Despite this long-lasting focus on progressivism, scholars have repeatedly reported how Norwegian schools and classrooms have continued to reproduce an established pattern of schooling based on plenary teaching and teacher-centred talk and interaction, in which the teachers decided, for the most part, what to do and when and how to do it (Klette, 2003). Haug (2004) revealed the same patterns and it is reasonable to ask if the Norwegian school system will follow the same trails in the new educational reform, the Knowledge Promotion (KD 2006). What is different in the Norwegian school of today compared to 10-12 years ago when the former reforms were implemented, is the digital revolution and digitisation of schooling. In the last 10 years Norway has become one of the world's leading countries in the accessibility of technology in its schools and society (Organisation for Economic Cooperation and Development [OECD],

2004; Vaage, 2005; Utdanningsdirektoratet, 2007). According to the report 'Broadband. Coverage analysis 2007' (Fornyings- og administrasjonsdepartementet [FAD], 2007), it is now possible for 98.3% of Norwegians to be connected to broadband and in 2007 60% of Norwegian households were connected to broadband. In upper secondary school we find that there is a ratio of 1.7 pupils per personal computer (PC). Some 41% of these pupils spend five hours or more every day in front of a screen in their leisure time outside school (Vaage, 2007). But despite high access and ICT use in general, we find a discrepancy between the policy makers' ambitious ICT vision and the actual use of ICT in Norwegian upper secondary schools (Kløvstad et al, 2005; Arnseth et al, 2007). This relatively low ICT use in school and subjects can no longer be explained by the lack of PC accessibility, but can mainly be explained by an important common factor across several studies; the lack of digitally competent teachers in school. In the new Norwegian educational reform digital literacy is highlighted as one of its five basic literacies in every subject at all stages. This expanded ICT focus implies increased recognition of the pedagogical potential of ICT and an urgent need to get teachers digitally competent to handle this mandatory digital literacy in the new national curricula and digitised school. Against this backdrop this study aims to focus on the emerging digital literacy among some teachers in leading-edge schools, how they are handling this new mandatory digital literacy in the national curricula and if they 'practise what they preach' in their everyday practice. Therefore the research question is: Is there a gap between teachers' intentions and ICT practices?

Some Teacher Challenges

The introduction of ICT into schools is still in its infancy, as implementing changes in schools is a time-consuming endeavour. In this process the teachers' role seems to be crucial. Both Sarason (1993) and Shulman (1997) found that educational change takes place through the teachers. According to Fullan (1991), 'Educational change depends on what teachers do and think – it is as simple and complex as that' (p. 71). Shulman (1997) added, 'For every strategy of reform, I believe that the engine of reform – its regulator and ultimately its bottleneck – is the classroom teacher' (p. 504).

In their roles as change agents as well as gatekeepers for educational change, teachers, as with other workers in society, are exposed to democratic tendencies, with a declining acceptance of authoritative leadership. Schools now have more autonomous students who are more conscious of their rights than of their duties. Negotiating skills are increasingly important, and these negotiating pupils can be a challenge to indulgent teachers.

Furthermore, the use of ICT has been associated with innovative work, project work, student-centred teaching, and student participation. This focus fits well with new pedagogical ideologies and reforms, but less well with assessments, activities, and national tests that are rewarded in terms of accountability regimes. Teachers are therefore faced with a dilemma. The innovative use of ICT is in line with pedagogical ideologies but is unsuitable for national tests, which raises the issue of how this dilemma is expressed in teachers' strategies and reasoning in regard to their practice.

Theoretical Background

Teachers' Voices

National tests and summative assessments provide status and an indication of how Norwegian students perform compared with students in other countries. New curricula, White Papers, and strategic plans initiate guidelines and objectives for future development and change in schools, and if these objectives are to be met teachers have to be involved in the entire process. Focusing on teachers' voices is likely to provide a valuable range of insights into educational restructuring and reform processes and new policy concerns and directives (Goodson, 1999).

The current deprofessionalisation of teaching has been a problem, with teachers becoming increasingly absent figures in both the classroom and public school debate. This is one of several factors involved in increasing demands for bureaucratic accountability, something which tends to undermine teacher autonomy. The dominant focus is on presentations of ideals, in the form of political and pedagogical ideologies, rather than the presentation and understanding of practice in

schools (Haug, 2005). Our knowledge about the situation in schools is thus inadequate. Interviewing teachers is therefore a preferred strategy for obtaining knowledge about teachers' thinking and for understanding the school environment.

Teachers are responsible designers of their classes' learning environments. Their consciousness of what they are doing and why they are doing it may, however, be absent and difficult to articulate. The expression *tacit knowledge* is often used in regard to this phenomenon (Polanyi, 1967). Teachers' reflections and answers may differ, depending on the subject and the context, and it is not an aim, or even a possibility, to formulate a general description of a single good educational practice.

However, the intention here is to offer a discussion in which teachers describe what they are already doing and why, rather than what they should be doing. In order to manage this, teachers must be able to reflect on their actions. Schön (1983) introduced the concepts of *reflection-in-action* and *reflection-on-action*. The ability to reflect in action is decisive for handling everyday practices, which are distinguished by complexity, uncertainty, unique situations, and value conflicts. The reflection-in-action process is more a matter of artistry than of instrumental, technical problem solving (Schön, 1983).

Technical rationality and the positivistic theory of knowledge therefore has reduced applicability to teachers' professional work (Schön, 1983). With a need for artistry and flexibility, teachers apparently build up their own practice theories (Handal & Lauvås, 2000) or folk pedagogies (Bruner, 1996). These self-made theories vary from teacher to teacher and school to school, and are a result of reflecting on action, or thinking back on what they have done in order to discover how their previous actions and reflections may have contributed to unexpected outcomes. Shulman (1987) called this theory building. It is distinctive to teachers' pedagogical content knowledge. This pedagogical content knowledge is developed, among other factors, through being reflective practitioners. In Shulman's view, pedagogical content knowledge is a form of practical knowledge that is used by teachers to guide their actions in highly contextualised classroom settings.

Shulman (1987) emphasised the importance of teachers in innovative work with school reforms, asserting that teachers know things not understood by others and can transform understanding, performance skills, or desired attitudes or values into pedagogical representations and actions. Teaching begins with each teacher's understanding of what is to be learned and how it is to be taught (Shulman, 1987, p. 227). In order to do this, teachers need some categories of knowledge. Shulman (1987) proposed the following categories. First is content knowledge, followed by general pedagogical knowledge, or such knowledge related to general teaching issues as teaching approaches and classroom management. Next he listed curriculum knowledge, or knowledge about such tools as schemes of work and resources, followed by pedagogical content knowledge, 'that special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding' (p. 227), knowledge of learners and their characteristics, knowledge of such educational contexts as groups, classes, the school and the wider community and cultures, and knowledge of educational ends, purposes, and values and their philosophical and historical grounds.

To characterise the complex ways in which teachers think about how particular content should be taught, Shulman (1987) argued that 'pedagogical content knowledge' (p. 9) is the content knowledge that deals with the teaching process, including the 'the ways of representing and formulating the subject that make it comprehensible to others' (p. 9). If teachers are to be successful they need alternative ways of representing their subjects. They need to confront both issues of content and pedagogy simultaneously by embodying 'the aspects of content most germane to its teachability' (Shulman, 1986, p. 9). This knowledge also includes an understanding of what makes the learning of specific topics easy or difficult. The kind of conceptions and preconceptions that students of different ages and backgrounds bring to learning is important to grasp. Teachers sometimes need knowledge to reorganise their understanding of learners because their preconceptions of students may be misconceptions.

Mishra & Koehler (2006) extended Shulman's definition to technological pedagogical content knowledge (TPCK), which builds on Shulman's (1986) formulation of pedagogical content

knowledge, and describes how ICT expands and challenges teachers' pedagogical content. TPCK will be further explained below.

The Introduction of ICT and Teacher's Technological Pedagogical Content Knowledge

The way ICT is used in teaching is influenced by the teachers' knowledge about their subject and how ICT is related to it. European Schoolnet (Balanskat et al, 2006) pointed out that teachers use ICT to support their existing pedagogies, and that it is used most when it fits best with traditional practices. Teachers use computers because their conceptions of using ICT already fit within their existing notions of effective teaching practices. Its greatest impact is with teachers who are experienced users and who have already made progress integrating ICT into their teaching. Teachers who perceive a highly positive impact of ICT use it in the most project-oriented, collaborative, and experimental ways. The ICT Test Bed Evaluation (Somekh et al, 2006) provides further evidence that teachers use ICT to support existing pedagogies:

New technologies that provide a good fit with existing practices, such as interactive whiteboards are first to be embedded, but others like video conferencing, digital video and virtual learning environments are now being incorporated, providing evidence of ongoing learning by the workforce. Training needs to continue to support innovative pedagogy. (p. 7)

With ICT, teachers tend to become advisors, critical dialogue partners, and leaders for specific subject domains. European Schoolnet (Balanskat et al, 2006) found that teachers did not yet exploit the creative potential of ICT by engaging students more actively in the production of knowledge. ICT is underexploited in creating learning environments where students are more actively engaged in the creation of knowledge, rather than just being passive consumers. Teachers have been given the task of integrating ICT into the curriculum, and they have to identify a way forward in a landscape where researchers do not agree whether ICT improves learning outcomes.

Higgins & Moseley (2001) pointed towards some important issues about the research into ICT in teaching and learning. Little research data has emerged on how ICT might contribute to effective teaching and learning, but Higgins & Moseley (2001) observed both *retrospective* pedagogies and *prospective* pedagogies for it. The retrospective pedagogies argue that ICT has the potential to support current pedagogy and improve attainment within the frameworks in which schools already operate. The prospective pedagogies suggest that unless teaching practices change, technology will not be widely integrated into primary classrooms because of a mismatch between teachers' beliefs about teaching and learning and their perceptions of the value of educational ICT.

Watson (2003) also emphasised the importance of teachers' beliefs in the new ICT environment, calling it a simplification to explain that teachers in the ICT environment are causing a shift from teaching to guiding and facilitation, moving from being a 'sage on the stage to guide on the side' (p. 33), as if current constructs of the act of teaching were dominated only by the transmitter-of-knowledge model. She argued that the act of teaching and the responsibility, sociology, and philosophy of teachers need greater understanding (Watson, 2003).

Mishra & Koehler (2006) tried to tie technology to Shulman's (1987, 1997) earlier work and developed a model of TPCK (Figure 1). This model emphasises the connections, interactions, affordances, and constraints between and among content, pedagogy, and technology. In this model, knowledge about content (C), pedagogy (P), and technology (T) is decisive for developing good teaching. The blending of domains, instead of treating them as separate bodies of knowledge, is central to this model. Having knowledge of subject matter and general pedagogical strategies, though necessary, is insufficient for good teachers. Mishra & Koehler (2006) did not argue that this TPCK approach is completely new, pointing to other scholars who have argued that knowledge about technology cannot be treated as context-free and that good teaching requires an understanding of how technology relates to pedagogy and content (Keating & Evans, 2001; Margerum-Leys & Marx, 2002; Lundeborg et al, 2003; Zhao, 2003; Hughes, 2005; Neiss, 2005). What sets Mishra & Koehler's (2006) approach apart is the specificity of their articulation of these relationships among content, pedagogy, and technology, noting that:

TPCK is the basis of good teaching with technology and requires an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge and to develop new epistemologies or strengthen old ones. (p. 1029)

The core of Mishra & Koehler's (2006) argument is that there is no single technological solution that applies for every teacher, every course, or every view of teaching. The technology knowledge mentioned is distinctly different from technology engineering or other technology disciplines:

Quality teaching requires developing a nuanced understanding of the complex relationships between technology, content, and pedagogy, and using this understanding to develop appropriate, context-specific strategies and representations. Productive technology integration in teaching needs to consider all three issues not in isolation, but rather within the complex relationships in the system defined by the three key elements. (Mishra & Koehler, 2006, p. 1029)

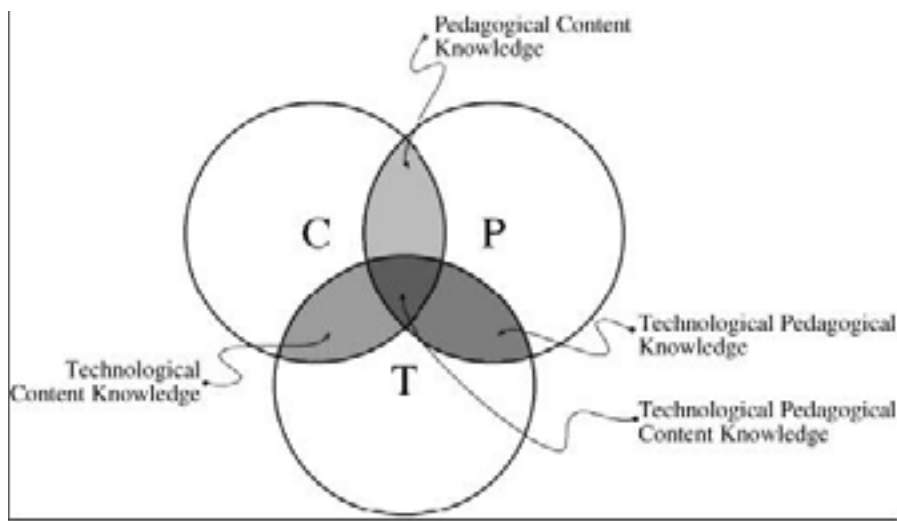


Figure 1. Technological pedagogical content knowledge (Mishra & Koehler, 2006).

TPCK involves multifaceted knowledge, and possessing this knowledge makes a difference, which implies that properly prepared teachers take advantage of the unique features of technology to teach content in ways they otherwise could not. Some teachers take students to computer labs and use the computers as notebooks in which students answer questions from their textbooks. Other teachers use computers to facilitate the engaging of students who are uncomfortable with traditional pedagogy. Computers increase teachers' options for alternative teaching strategies and content representation. Koehler et al (2007) concluded that:

At the heart of TPCK is the dynamic, transactional relationship between content, pedagogy and technology. Good teaching with technology requires understanding the mutually reinforcing relationships between all three elements taken together to develop appropriate, context specific strategies and representations. (p. 741)

This composite knowledge is important because it is not only about what the technology can do for them as teachers, but also about what it cannot do. Teachers' work in classrooms is constructed from continuous exposure, experience, routine, and ritual, and is embedded within a set of personal strategies and values. This construct is a part of teachers' professional development. TPCK is also a part of that development.

Krumsvik (2007a) emphasised this tight relationship among pedagogy, content and technology in his attempt to describe digital literacy and to explain how digital literacy is developed (see Figure 2). This model highlights both the *awareness journey* (vertical axis) and the *proficiency journey* every teacher has to take to increase their digital competency in general. The awareness journey consists of development through four steps which take teachers from digital insecurity and incompetence to high digital awareness and competence. The proficiency journey consists of teachers moving from just adopting the technology towards innovation and the ability to create new digital artefacts by themselves.

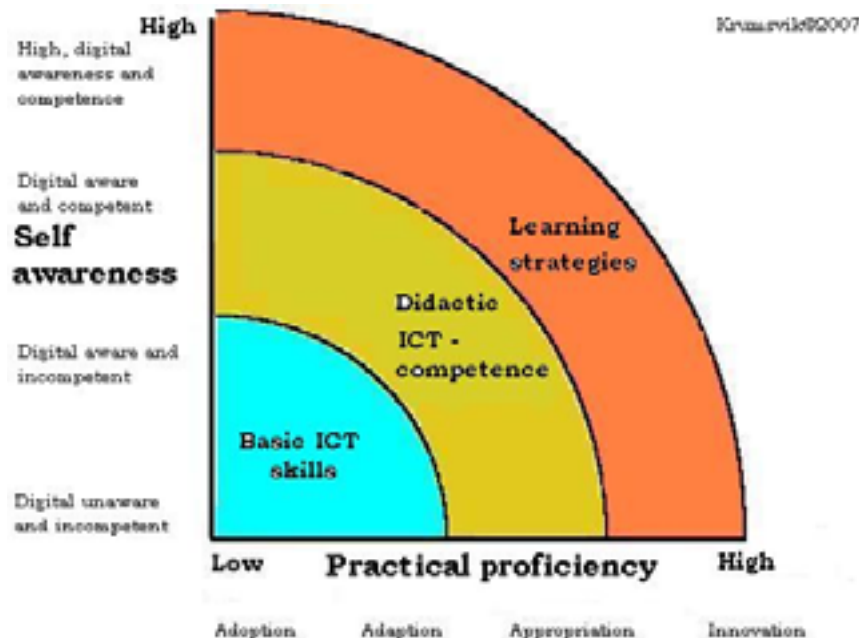


Figure 2. Digital literacy model for in-service teachers (Krumsvik 2007a).

In the centre of the model one can recognise the symbiosis between the awareness axis and the proficiency axis, which together contribute to teachers' development of their digital literacy. The first level consists of basic ICT skills, which in general are no longer the main problem for teachers in Norway. It is the next level, didactic ICT competence, which is now the teachers' main challenge. This level demands that teachers integrate ICT seamlessly into their subjects and use it actively in those subjects to increase the students' learning potential. This, again, demands a focus on the next level, which is learning strategies. This involves the awareness that pupils now construct knowledge in new ways compared to earlier generations, and that technology in general has an important position in this digital knowledge construction. Krumsvik's (2007a) model illustrates the complexity of developing teachers' digital literacy and the importance of reflection in this process, and can be seen as a part of the more holistic term, TPCK, presented earlier.

Method

This study was designed to employ generic qualitative research (Merriam, 1998) and case study research (Yin, 1994). It combines the four data-collection techniques of document analysis, semi-structured interviews, observations in classrooms, and recall interviews, conducted both one on one and in groups, assisted by video from classrooms.

The use of the different data-collection techniques resulted in discrete but interrelated sets of data and served to increase the study's authenticity and to provide added depth to the investigation into teachers' thinking. This form of data collection, which Denzin & Lincoln (2000) called *data triangulation*, served as a means by which the weaknesses of one data collection technique could be compensated for by the strengths of another technique. Methodological difficulties arise in any attempt to study teachers' thinking. Thinking is not directly observable in the classroom and may

be presented differently to different audiences. Care must therefore be taken in how teachers' thinking is investigated. Interviews were the largest data source and Kvale's (2001) model of seven stages in an interview inquiry was used.

Selection of Participants

The sample selection in this case study was based on purposeful sampling (Patton, 1990) in leading-edge schools (Schofield, 1990). The sample was a unique sample (Merriam, 1998), in which two upper secondary school teachers from two different schools were selected. These teachers were chosen 'based on the expected reasonable coverage of the phenomenon, given the purpose of the study' (Patton, 1990, p. 186) from a larger case study which involved four leading-edge schools and 13 teachers (Almås & Krumsvik, 2007). All 13 teachers in this previous study were classified as digitally competent and we selected two of these to be our primary informants in this study. But in the part of the study where these two teachers are discussing the video with the main researcher and their own colleagues (phase e), we have taken in some citations from other teachers in this actual discussion to complement our two primary informants.

A digitally competent teacher ...	has appropriate formal ICT competence, whether as an ICT teacher or through other education in ICT
	has participated in PILOT (Project: Innovation, Learning, Organisation and Technology) or other extensive ICT project
	has worked as teacher for a minimum of five years and has used ICT in his or her employment

Table I. Description of a digitally competent teacher.

Digitally competent teachers are not necessarily those with the most extensive experience with ICT. Digital competence embraces the awareness of, and the ability to see, when ICT ought not to be used. Table I defines digitally competent teachers for the purposes of this study.

Context

One intention of the selection of digitally competent teachers is to find teachers who were familiar with the expanding variety of pedagogical techniques and who practised in classroom environments where all students had their own wireless laptop, connected to the Internet. These teachers were also equipped with their own laptops which could easily be connected to a projector in the ceiling. The classrooms had ordinary blackboards, which were often used. Each classroom also contained an overhead projector. The subjects involved were social studies, English, and religion. Students were seated alone at individual tables, but some tables seated two.

One teacher emphasised that power supply devices were a problem, as she sometimes nearly stumbled over the cables when moving between the table rows to help the students. The teachers moved often during each teaching lesson.

Data Collection

Data collection was done in six steps. Two teachers were followed through these steps, which are briefly described in Table II.

	Time-frame	Rationale/purpose
(1) Document analysis	Previous years	To obtain knowledge about the context. To discover the extent to which the schools are prepared for an ICT focus.
(2) Interviews with teachers	1 hour	To discover any differences between teachers' perceptions and understanding of ICT use and the schools' focus. To discover what is important for teachers when it comes to the use of ICT.
(3) Videotaping of teachers in their classrooms	1-2 hours	To discover any obvious differences in collected data from the first steps and the observations in their classrooms. To discover new aspects of relevance which have not been mentioned earlier.

(4) Teachers watch the videos of themselves	1.5 hours	To help teachers reflect on what is going on in their classrooms, what they are doing, and why.
(5) Teachers discuss the videos with the researcher	1 hour	To provide the teachers with the opportunity to explain what they did in the recorded teaching situations.
(6) Teachers discuss the videos with the researcher and their colleagues	1.5 hours	To provide a new opportunity to explain what happened, and to allow colleagues to confirm situations and add information.

Table II. The different steps in the data collection.

Document Analysis

The document analysis (step 1) involved the plans and research reports of a previous ICT project called 'Project: Innovation, Learning, Organisation and Technology' (PILOT) at the chosen schools (Almås, 2004; Erstad, 2004; Krumsvik, 2006a), and formed the basis for the interview guide. This document analysis was therefore based on public records and research-generated documents (Merriam, 1998). It is only the entry point for knowledge of the context.

Interviews

This limited case study utilised only two informants, and the observations and interviews were conducted by the same researcher. In order to provide the study with depth, this study also employed Kvale's (2001) proposal for seven interview stages for its analysis. Kvale raised new questions about the interview statements from different interpretation contexts, and the validity of these interpretations is related to different validity communities. Therefore, as a starting point for addressing such internal validity issues, this study used Kvale's (2001) three contexts for interpretation. These contexts are self-understanding by the interviewee, critical understanding based on common sense by the general public, and theoretical understanding. In the first context it is essential to have an understanding of each informant's everyday reality and to be faithful to his or her understanding of the same reality. In the second context the interpretation has a broader framework of understanding than the interviewer's own. It means that we as researchers may be critical about what is being said and can focus either on the content of statements or on the people behind them. This study used the third context's understanding to interpret statements within a theoretical framework, using different theoretical lenses to handle the issues involved.

To increase to internal validity of the interview portion of the case study we expanded the number of stages in the validation process and partly expanded the number of validity communities (Kvale, 2001). This process consisted of (a) videotaped interviews with the teachers, (b) videotaping the teachers in their classrooms, (c) teachers watching the videos of themselves, (d) the teachers discussing the video with the main researcher, (e) the teachers discussing the video with the main researcher and their own colleagues, (f) the main researcher engaging in informal video discussions with some colleagues at work, (g) the researchers selecting clips from the interviews and analysing them in the preliminary article, (h) the community of four researchers responding directly to the chosen clips from the interviews and accessing the preliminary analysis through Google Docs, and (i) validating the interview clips and analysis in this article by the journal's referees and researchers community.

The videos in which the teachers look at themselves and which they later discuss with the researcher function as a validation of the interviewers' own understanding and can be attached to stages one (a) through five (e). The video discussion with colleagues functions as the general public, common-sense validation and can be attached to stage six (f). Kvale's (2001) third validation community, the research community, was the research community at Stord/Haugesund University College and University of Bergen, and can be attached to stages seven (g) through nine (i). In this way we expanded the first and the third validity communities to increase the internal validity of the interviews. As a general validity summary of these nine stages, we as researchers not only reported teachers' practices, we also showed them as a part of a realistic realism (Latour 1999). In this way we decreased the bias attached to presenting just the researchers' voices and interpretations in academic texts.

The analysis of the interviews started once the first interview was conducted. This analysis was made after reading the reports and making observations at the school. We used Kvale's (2001) meaning condensation as the methodological entry point for the analysis of the interviews. We identified key patterns from each school from the document reviews, interviews, and observations. These categories were consistent with the Technological Pedagogical Content Knowledge (TPCK) framework.

Observations

The main researcher during observations can be defined as an *observer as participant* (Merriam, 1998) and a *collaborative partner* (McTaggart, 1991). This means that the main researcher is a researcher-participant and one 'who participates in a social situation but is personally partially involved, so that he can function as a researcher' (Gans, 1982, p. 54). The teachers were observed for 90 minutes in their classrooms, the entire sessions being videotaped and combined with field notes (Merriam, 1998). The observation periods were selected through discussion between the teachers and the researcher. We strived to find a relatively normal lesson without the obvious use of ICT or other irregular activities. The students were informed of the inquiry and asked to behave normally. During the lessons the researcher sat in front of the students and videotaped only the teachers. Sometimes the researcher moved to the back of the classroom, behind the students, to get a better shot of a teacher. Student activity is an important and interesting part of life in a classroom, but because of the age of the students it was not possible to videotape them without the permission of their parents. The researcher observed the activity taking place outside the camera shot and wrote down the observations in a notebook as field notes.

The observations were analysed in light of the already-worked-out interviews and based on the constant comparative method (Merriam, 1998). There were correlations between interviews and observations, allowing new perspectives to appear. Both the researcher and the teachers on their own further analysed the observations. Both worked through the video and picked up five or six situations which were typical of the observed teaching. ICT would probably be a tool in these situations. Because of these situations, the follow-up interviews subsequent to the teaching lessons enabled a new and extended discussion of their practice.

External Validity and Generalisation

This is a qualitative case study with a unique sample in leading-edge schools, and this has consequences for issues involving generalisation. This study is based on what Schofield (1990) called *what could be*, as well as reader or user generalisations. Firestone (1993) called this a case-to-case transfer, and where 'It is the reader who has to ask, what is there in this study that I can apply to my own situation, and what clearly does not apply' (Walker, 1980, p. 34). This study uses *rich* and *thick descriptions* (Geertz, 1973) to describe its findings.

Empirical Analysis

In this section the empirical data are divided into four chronological sections, following Merriam's (1998) step-by-step process. The first step is a description of a context in change. The second is about teachers' thoughts about use of ICT in teaching, and the third is a description of the teachers' lessons based on observations. The last section focuses on the teachers' and their colleagues' reflections on the videos from their classrooms. These sections crystallise the factors which end up in the discussions connected to TPCK's three concepts of technological knowledge, pedagogical knowledge, and content knowledge.

Context of Teaching

This investigation built on an ICT project which started in 1999, and a retrospective description is necessary before presenting data from current practice. The schools involved participated in PILOT from 1999 to 2003 and worked out plans for their own implementation of ICT. PILOT's main

objective was to develop the pedagogical and organisational potential provided by ICT in education and to report knowledge about it.

One important feature of PILOT was the use of a bottom-up strategy. No researchers or public authorities told the teachers and principals what to do. The activities had to fit in with existing school cultures, ongoing projects, and the challenges in which they were engaged at the respective schools. This open and broad starting point resulted in huge variations in the projects. The project plans were characterised by activities for increasing the pupils' ability to take part in collaboration, communication, creativity, and innovation. For instance, School B's plans included:

In PILOT we will concentrate on organising the school day in such a manner that it encourages the pupils to take responsibility for their own learning, and facilitates problem-based learning, the use of ICT, and differentiation ... The fundamental principle should be that the pupils are to be producers, not consumers. (School B Project plan, 2000, p. 2)

The role of the teacher should be changed from an all-knowing mediating teacher to a coach or learning supervisor. (School B Project plan, 2000, p. 6)

This is a short extract from one plan, but words like activity, collaboration and problem-based learning appeared repeatedly. The plans were influenced by new trends in theories for learning, in which the pupils themselves are active participants in the learning process and responsible for their own learning. The plans were also influenced by the Norwegian plans for ICT in education since 1990, which contain optimism about ICT as a motivating factor with an effective impact on the learning process.

PILOT began after a period of discussions about the amount of computer equipment in schools. Many teachers claimed a lack of computers as their reason for not integrating computers in their instruction. The Ministry of Education and Research disregarded this and refused the schools' requests for the funding of more computers supplied by PILOT. Pedagogy with a sociocultural approach, promoting an approach which emphasises the social, cultural, and contextual dimensions and which pointed out that learning takes place within social interaction, dominated the discussions.

This first section of data presentation distinguishes Shulman's (1987, 1997) pedagogical knowledge. It is a discussion about general pedagogical processes and practices, not connected to any special subject. The ICT considerations are part of overall educational purposes that are rewarded in terms of the accountability regimes.

Status in 2006 (and 2007)

Three years after finishing PILOT, the teachers in this inquiry continued to have difficulties with extracting the main issues from the project plans. It is evident that their schools have focused on school development and have taken continuous part in new projects. This makes it problematic for teachers to navigate between projects. A teacher from School A reported in 2006:

I can't remember the explicit focus in PILOT, except that ICT should be used in every subject. Our principal has always worked for obtaining new projects and funding for our school. He is brilliant.

Neither of the two teachers in this investigation was involved in the construction of project plans, so there might also be problems concerning lack of ownership. Both of them found PILOT to be a successful project which delivered valuable experiences to their school. The written plans and documents from PILOT were strategic and adapted to national ICT plans. Even if it had been a success, they did not explain it as an easy development process. It was difficult for project members to put forward a common understanding of how and why they were changing the school.

In the first interview the teachers stated that ICT is a notably important part of school today and they could not manage without it. This is interesting, because they indicated that ICT had not fundamentally changed their practice. The ways in which they teach or the ways they design learning experiences in the classroom were well known and traditionally executed. They said that laptops were primarily used for writing, taking notes, completing homework assignments, keeping organised, communicating with peers and teachers, and researching topics on the Internet. In

describing the ways in which ICT has had an impact on their classroom practices, they were modest as to what they saw as the consequences of the introduction of ICT. The question of whether the teachers' reported dependence on the computer, which is repeated several times in the data, is connected to conditions other than their performance and students' activities in the classroom (this will be discussed later in this article).

When the teachers recalled their early thoughts and work with ICT, they reported never expecting ICT to be a tool which would totally reorganise the classroom and the students' attendance time. Students could work from home during some periods and perform special activities outside of school, but for the majority of students, in general the school is a desirable place to be. Teacher One reported:

We have been through a decade with too much focus on students' responsibility for their own learning. Many of them experience this responsibility and freedom of choice as challenging. This is because of the information overload, but also because of changes in society in general. Students need directives and milestones and want follow-ups.

Their work as teachers has gone beyond teaching being an activity which only occurs in classrooms. A range of factors is involved in their organisation of the learning environment. A knowledge of students' social conditions and changes in society is now a part of their pedagogical considerations. According to Teacher One, 'Students of this generation have challenges at school, but not at the least in society, and need teachers or other adults who care about them and give advice'. Teacher Five added, 'The weakness with problem-based teaching, project work, and tasks where students were responsible for their own work is that it is amplifying already-existing inequality in classes'.

Teachers do focus on their students, and those interviewed for this study emphasised the importance of giving students personalised teaching. This means that students have different starting points for learning, and that this must be considered. Identifying each student's strengths and preferences across a spectrum of physiological, sociological, psychological, and emotional elements is challenging but necessary. This study's informants reported that they tried to meet each student on her or his own level and to motivate all of them to further and deeper learning. They said that they assumed that ICT may be a helpful tool in this work, but without explaining this further.

What emerged in the deeper discussion is that the respondents did not see any shortcut for students' learning or for the teachers' determinations of their students' abilities. Such physical contact between teachers and students as eye contact and a pat on the shoulder is necessary to create students' work satisfaction and good conditions for learning. This is an important point for teachers, and the informants repeated it several times, such as Teacher Two saying, 'Seeing every student is my bad conscience', and it is clear that ICT cannot handle this dilemma by itself.

Although secondary school teachers are engaged in their subject, our respondents barely focused on subject and content knowledge when they talked about their teaching. Questions about this had to be explicit. They generally answered that content knowledge is a given, and went on to point out that their overview is important in building scaffolds for the students and making them see their assessments as a part of a greater whole. Teachers frequently mentioned connections to earlier curricula in their lectures (see video 1):

<http://www.wwwords.co.uk/rcie/content/video/3/2/video1.wmv>

Three years after PILOT, it is again acceptable to ask for satisfactory access to computers, and there is a consensus about the value of one laptop per student. In addition, the schools have a larger number of printers, video projectors, and digital cameras. One of the schools has already trialled the 1:1 dimension for four years. Again, access is important, but our teachers' attitude to equipment discussion is, as Teacher Two said, 'there will always be technological problems and claims for better solutions, and the challenge for teachers is to solve the unforeseen situations which occur' (see video 2):

<http://www.wwwords.co.uk/rcie/content/video/3/2/video2.wmv>

Teachers report being tired of always planning their teaching with something up their sleeves. New technical challenges will always emerge, which means that one facet of teachers' digital literacy is the ability to handle unforeseen situations and critical incidents.

A Characteristic of Teaching Lessons Based on Observations

Time	Teacher activity	Student activity
0-2 mins	Introduces the lesson; registers absence of students. Gives instruction for the next minute. 'Find the test on ITL and answer the few questions I have made for you'. 'Meanwhile I'll check your homework'.	See video 3: http://www.wwwords.co.uk/rcie/content/video/3/2/video3.wmv Get their homework on the laptops.
2-6 mins	Walks from student to student and approves their homework.	See video 4: http://www.wwwords.co.uk/rcie/content/video/3/2/video4.wmv
6-36 mins	Examines difficulties from their homework in plenum. Starts the overhead projector and writes keywords on the blackboard. Request for dialogue by always asking the students.	Follow questions from homework step by step, and are challenged by questions from teacher anytime. Some students are reading news on the Internet.
36-90 mins	Introduces two new chapters from textbook. Has prepared a lecture with a PowerPoint presentation. The five first minutes are characterised by technical problems and the teacher is a bit stressed.	Some technical problems with the projector give students five minutes' break to surf the Internet. Some messages were sent by MSN and football results from yesterday were confirmed. A boy in front gave some advice on how to choose the right input channel to the projector. After a while everything is okay.

Table III. Religion – 90 minutes.

Time	Teacher activity	Student activity
0-5 mins	Introduces the lesson in front of class. Gives instruction for the next few minutes. 'Who is going to have a presentation today?' The teacher writes keywords on the blackboard. Two students connect their laptop to the video projector and a power point appears on the screen. Parallel activities are in progress.	Starting their laptops. Three students prepare their presentation, the other students are working with smaller tasks. There is no problem with the technology.
5-19 mins	The teacher is seated by the door and three students present their project homework one after another.	Students listen to the presentations and give feedback to the presenters. The presenters seem not to be reluctant to talk to the entire class.
19-21 mins	Students are finished and the teacher encourages the class to discussion. Starts the overhead projector and writes keywords on the blackboard. Requests for dialogue by always asking the students.	Some students are reading news on the Internet. A researcher sits behind them and observes their surfing on the net, but it seems like they do not care about that.
21-36 mins	Presentation on the blackboard with four keywords. Ask for a discussion. 'Don't look at your screens'. The teacher opens his book and requests students to do the same. 'Look at page 177. What does that table tell us?' Discussion about important concepts in their textbook.	The students are highly active in the discussion. Half of the class participates and the rest follows as spectators.
36 mins	The teacher hands out tasks to work with the rest of the lesson. 'Everyone must remember to log in to the discussion forum on Its Learning and write a comment'. The teacher walks among the students and sees how they work.	Students start working in textbooks and on pc. Two students decide to leave classroom and look up the study room.

Table IV. Social studies – 90 minutes.

Simply watching the videotaped lesson produces the impression that the teachers were executing traditional lecturing in front of the blackboard (see video 5):

<http://www.wwwords.co.uk/rcie/content/video/3/2/video5.wmv>

Instead of absolute fidelity to the blackboard, they ensured variation in their lecturing by using the video projector and overhead projector (see video 6):

<http://www.wwwords.co.uk/rcie/content/video/3/2/video6.wmv>

Observations confirmed that they were incorporating the computers in their existing practices. Tables III and IV give a short characteristic of how a teaching lesson is accomplished. The observation in class revealed that the teacher has an extended work day.

In the last five minutes of the lesson the teacher reminds the students to be active in the discussion on a learning-management system, called *Its Learning*. He had planned to check it out at about 11 in the evening (see video 7):

<http://www.wwwords.co.uk/rcie/content/video/3/2/video7.wmv>

If the students see that their teacher is online they may send him or her instant messages with questions from their homework. The teacher answers, irrespective of the time, but knows that he must define the limits for this kind of after-hours work. This teacher is comfortable with *Its Learning* and says it is a helpful tool for organising the teaching materials and giving messages. The discussion forum on the Internet is not a substitute for discussions in class, but rather a valuable supplement, because the participants on the Internet are different group than those who ask questions in class. It is often the quiet students who like the Internet discussions.

*What was the Focus of the Open Discussions with their
Colleagues and the Researcher after Watching the Videos?*

This study's informants were unfamiliar or unaccustomed with using the video capturing of their own teaching and the subsequent discussions about their practice. Pedagogical discussions, based on their own contexts, are usual between colleagues, but rarely with researchers or other outsiders. They were anxious about this new situation, but at the same time confident about their work in class. At an early stage in this session it became clear how one teacher looked at things other than her colleagues and the researcher, showing frustration about using the same words too often during one teaching lesson, in particular, 'Ikkje sant [You see?]

Another example is linked to prevailing practices and discussions about teachers' selections of teaching methods. Teacher One commented, 'This isn't good. I am talking too much', when he was looking at the video. The researcher responded, 'You are only talking for five minutes'. Teacher One replied, 'Oh, really? But I am glad this doesn't apply for wage talks with my principal'. The researcher then asked, 'Is there anything you want to change then?' Teacher One replied, 'Actually, no' (see video 8):

<http://www.wwwords.co.uk/rcie/content/video/3/2/video8.wmv>

This example shows that the teacher knew about new student-active pedagogical tendencies and was sensitive to criticism of teachers who talk, or lecture, too much. Currently, the ideal classroom involves students engaged in talking and the teacher acting as a guide or coach on the side.

Another teacher reported that it was difficult to talk to students for an entire hour, and that dialogue is necessary to keep their concentration (see video 9):

<http://www.wwwords.co.uk/rcie/content/video/3/2/video9.wmv>

Teacher One is an experienced, self-confident teacher and admitted that he was satisfied with his own teaching (see video 10):

<http://www.wwwords.co.uk/rcie/content/video/3/2/video10.wmv>

The use of video brought our discussions to a micro level about teachers' work. Video and snapshots from the classroom, combined with their memory, caused a movement in our discussions from the micro level to a macro level. Respondents talked about concrete situations

involving how homework and assignments are performed, and later moved to a macro level where they explained such situations as parts of a greater whole. A key here was how each subject changes throughout a year. These changes are not identical for each subject (see video 11):

<http://www.wwwords.co.uk/rcie/content/video/3/2/video11.wmv>

The ability to handle this change of focus, working methods, and holistic understanding of how a subject is taught is a part of teachers' professional development and TPCK. In a discussion in which the totality is so complex and important, it is difficult to focus on such single factors as ICT. One other factor which seems important, for instance, is examinations. Examinations and the way students are evaluated constitute a steering instrument, and the teachers' teaching is designed to accommodate examinations (see video 12):

<http://www.wwwords.co.uk/rcie/content/video/3/2/video12.wmv>

The use of ICT and project work is reduced near the examination periods because the examinations do not reflect and respond to new working methods. As Teacher One said, 'As long as my external examiner is closely tied to the textbook and definitions of concepts from each chapter in this book, I have to prepare my students to provide that kind of answers. But I did not like it'. Certainly, it is possible to choose a new way to accommodate examinations, but teachers are dependent on the external examiners and their goodwill and positive attitudes toward new examinations.

Structure is important in regard to planning a complete school year. The national curriculum supports this work, but it is also important for teachers to structure each lesson. The students should know what the teacher has prepared for them to do, and through information on *Its Learning*, students found it possible to prepare themselves (see video 13):

<http://www.wwwords.co.uk/rcie/content/video/3/2/video13.wmv>

Even though structure is important, the unpredictability inherent in the teaching profession makes their work exciting, but also demanding (see video 14):

<http://www.wwwords.co.uk/rcie/content/video/3/2/video14.wmv>

The teachers reported feeling comfortable with their choice of career and talked about the teaching profession as a vocation. This is also a reason why they still worked as teachers. Teacher One said, 'I have found my own way of doing things, and the unpredictability every day at school makes my day varied and meaningful. Humour, structure, variation, and care about every student is important for me'.

The respondents' colleagues appeared to be uncertain about how to comment on the classroom videos, and seemed careful in their comments, exhibiting no laughter or other condescending reactions when they watched them. Instead, they nodded in recognition of classroom situations and dilemmas. Teacher Two, for example, said, 'Oh, that is typical! NN is always joking and answering me like that [laughter]'.

The teachers shared plans, ideas, and discussion about situations from their classes, but they tended to find their own way in performing as teachers. Teacher Four, for instance, said, 'Oh, I thought you were clever and used the laptops all the time. It is good to see that you are doing other things as well'. To put this quote in context, Teacher 4 claimed that computers are not used as much as they should be. It is expensive to invest in laptops for every student, whether it is done by the school or by the students themselves. Teachers are committed to using them frequently to justify the cost.

The discussions with colleagues revealed that even if tendencies existed to share information, ideas, and access to each others' classrooms in learning management systems, people still recognise the traditional image of the teacher. They perform as lonely and autonomous practitioners in their self-contained classrooms (Hargreaves, 1993).

After a while the respondents' colleagues related the discussions to their own teaching and brought examples from what they do themselves, rather than limiting the discussions to the video. It became clear that these teachers were accustomed to reflecting on their actions, and it seemed as if they enjoyed getting feedback from their colleagues. They acted as responsible and autonomous teachers and declared that ICT has been an important part of their work, although at the time they

had made few changes in their teaching, noting that ICT is widely used in tasks outside the classroom. Teacher Three said, 'The Internet is a fantastic remedy, but I have never spent so much time on preparing my lessons as I do now' (see video 15):

<http://www.wwwords.co.uk/rcie/content/video/3/2/video15.wmv>

Teacher Two and colleagues summarised this by saying, 'The most important thing for me is to focus on subject knowledge, engagement, and a good atmosphere in class so that everyone is comfortable and learns what is meant to be learned'. This prevailing perspective has not changed because of the appearance of the information society.

Discussion

It is difficult for practitioners to articulate their professional knowledge, and our interviews revealed that teachers struggle with explanations of their ICT use because teaching is a complex activity and ICT cannot be seen as separate from it. Understanding teachers' practices is also a challenge because of the complexity and simultaneous activities which occur in classrooms. Through the four stages of data analysis it became clear that the ICT discussion is intertwined with the issue of new pedagogy. A distinct feature in the discussions was the teachers' reflections about individual, personalised teaching and differentiation. Another distinct feature was that they said they thought holistically about the totality of the experience and society rather than about one single competence.

The teachers were characterised by a positive attitude towards ICT and expressed beliefs about the contribution that ICT can make to the process of teaching, learning, and classroom management. Even if their school's project plans had visions of how ICT could change teaching and the role of teachers, our respondents themselves did not admit that they had an exaggerated belief about ICT's value.

They have the ability to control ICT use in their classrooms and to cope with technical failures, and have colleagues who can provide support, encourage use, and constitute a learning community. The Internet provides large amounts of professional and subject-related information. It is also a basis for such new forms for work as collaboration, blogging, chatting, and video sharing. They are aware of the new possibilities and have to compare these with already-existing, well-known methods and remedies. That someone can do something does not automatically also make it something desirable to do, and they consider only a handful of tactics to be educationally desirable. As Sarason (1984) noted, not everything possible, wondrous as it might be, is necessarily also desirable.

Our informants appreciated and evaluated new opportunities from the perspective of the frameworks and contexts of which they are a part. The new national curriculum, K06 (Kunnskapsdepartementet, 2006), does not prefer any teaching methods over others. Teachers have freedom to choose from their own teaching repertoire, a repertoire which consists of traditional teaching methods and the new teaching possibilities which ICT reveals. Experiences from such ICT projects as PILOT and discussions with the teachers taking part in them confirm Mishra & Koehler's (2006) argument that there is no single solution that applies for every teacher, every course, or every view of teaching. As teacher Two said, 'When you have performed as teacher for a while, you know what works and doesn't work. For every new activity or tool you want to integrate, you start to think about the totality and consequences' (see video 16):

<http://www.wwwords.co.uk/rcie/content/video/3/2/video16.wmv>.

This study has emphasised that teachers are eclectic, autonomous practitioners and use their technological, pedagogical, and content knowledge to see connections and to orchestrate the learning environment on behalf of their students.

One way of describing teachers' repertoires is to go back to the term TPCK – technological pedagogical content knowledge. This term encompasses three kinds of knowledge. Pedagogical knowledge is discussed most frequently through data analysis. Teachers' pedagogical knowledge, the teaching process, and what the students bring with them are obvious when our respondents talked about their work. Everybody has to be included. Everyone has to be seen and achievable tasks must be adjusted for them. The students are in focus and the importance of giving students

personalised teaching must be emphasised. The ability to reflect and prepare for this individualisation, to which the student must also contribute, is a part of teachers' pedagogical knowledge. Pedagogical considerations should be made in combination with content considerations.

As noted earlier, the innovative use of ICT is effective pedagogy but is not suitable for national tests. This raises the question of how this dilemma is expressed in teachers' strategies and in their reasoning about their practice. As mentioned above, teachers are allowed to make their own choices concerning their pedagogical methods, and they perform their work with extensive experience and consideration. The point which seems to be most significant is dealing with examinations. It is from the perspective of the question of how students will be measured in examinations that such other factors as ICT must be considered.

Another interesting dilemma is that every teacher involved in this inquiry maintained that they could no longer manage without ICT. This shows how their digital literacy has developed, from seeing ICT 'just as a simple tool', to be aware of the possibilities ICT might give in their everyday practice as a teacher. We might say that they have taken further steps in their 'awareness journey' and 'proficiency journey', tied to Krumsvik's (2007a) digital literacy model. This model underlines the importance of awareness and self-reflection in the process of becoming more digitally confident, and these teachers have altered their perception of ICT in this development process.

However, they admitted that ICT had not fundamentally changed the ways in which they taught or the ways they designed learning experiences for their classrooms. This dependence on ICT may be explained in many ways, but it is clear that they can solve many administrative tasks, such as general emailing, documentation of meetings, and recording students' marks and absences from class, by using computers. Other administrative uses include disseminating information from the schools' leadership and facilitating communication between colleagues and students. Such jobs are a part of teachers' work days, but they are not necessarily a part of what they define as teaching. They also mentioned computers as an important tool for preparing lessons, and one teacher declared that he had never spent so much time preparing his lessons as recently, the reason being the Internet and updated, interesting information. This shows a typical situation in the development of digital literacy among teachers; it takes time to fully recognise the potential of ICT in education and it takes time to develop a didactic ICT competence in their subject teaching (Krumsvik, 2006a, b; 2007a, b).

As a summary we think it is reasonable to claim that computers play an important role in teachers' work, and are also important for students. Students are now able to experience that learning occurs outside the classroom, and they take their laptops with them for many hours every day. They write, take notes, communicate, search, read, and update themselves using Internet. This means that if the extended use of laptops were difficult to observe in a few lessons in this inquiry, it is because the use of ICT exists to a large extent outside of classrooms. The dependence our informants described can thereby explain that outside activity is an important part of their learning community. And even though this emerging symbiosis between formal and informal learning arenas has interesting potential, it will not reach its full potential until teachers in general become digitally confident to see how this can give a new entry point for learning strategies and knowledge construction (third level of Krumsvik's model (Krumsvik, 2007a).

Conclusion

This study has not managed to measure a difference between what teachers do and what they had planned to do some years ago. It also found small differences between their explanations of their current teaching practices and the video recordings of their classes. This study sample's limited size must be taken into consideration in addressing the question of how change can be presented. An extended period together with the teachers in their classrooms would be ideal for presenting their practices more exactly. However, the discussions with colleagues and the researcher functioned as a methodological enterprise which confirmed and explained the interviews' results.

Established teaching methods still exist and work well. Teachers often use lectures and homework with questions leading to the next lesson. Our respondents have accepted the arrival of computers and they make continuous attempts toward new pedagogical integrations. They have

worked as teachers for several years and know the educational system. Their ability to navigate in technology-rich classrooms, their TPACK, has emerged and been developed through experience and reflection. It has become a part of their professional development and their digital literacy.

Changing pedagogical practices is a comprehensive task. New learning resources and computers are not enough. Still, it is difficult to see prospective changes in an organisation of which the teachers themselves are a part. Some changes, however, are evident. One example is the contents of the discussions, which were neither for nor against ICT in teaching. Consensus also exists about the vision of one laptop per student.

This study's teacher-respondents had experience, and the ability to learn from experience is important when reforms and new tools appear. The promotion of knowledge encourages teachers to create conditions in which students will be creative, involved, responsible, and inventive. Teachers are asked to create conditions for learning that they may never have encountered before themselves. Under these conditions, teachers must learn to anticipate the unexpected. Our respondents reported that this unpredictability makes it worthwhile to be a teacher. It is obvious that they have learned from the experiences they have created for their students, and have therefore used different teaching strategies from class to class and subject to subject. If teachers do not feel comfortable with changes, teaching practices may stay the same. Our informants have developed, and have continued to develop, a digital pedagogical content knowledge which seems to be strongly needed among teachers in the digitised school of today. Against this backdrop we find that there is still a gap between teachers' intentions and ICT practices, but the study shows at the same time that this gap is decreasing.

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References

- Almås, A.G. (2004) *Innovasjon, IKT og læringssyn. PILOT* [Innovation, ICT, and learning perspectives. PILOT. Partial report Rogaland and Hordaland]. ITU series no. 26. Oslo: Unipub (in Norwegian).
- Almås, A.G. & Krumsvik, R. (2007) Digitally Literate Teachers in Leading Edge Schools in Norway, *Journal of In-Service Education*, 33(4), 479-497. <http://dx.doi.org/10.1080/13674580701687864>
- Arnseth, H.C., Hatlevik, O., Kløvstad, V., Kristiansen, T. & Ottestad, G. (2007) *ITU Monitor 2007. Skolens digitale tilstand 2007* [ITU Monitor 2007. The Digital Conditions in School 2007]. Oslo: Forsknings- og kompetansenettverk for IT i utdanning (in Norwegian).
- Balanskat, A., Blamire, R. & Kefalla, S. (2006) *The ICT Impact Report: a review of studies of ICT impact on schools in Europe*. European Schoolnet. http://insight.eun.org/ww/en/pub/insight/misc/specialreports/impact_study.htm (accessed 29 November 2007).
- Bruner, J. (1996) *The Culture of Education*. Cambridge, MA: Harvard University Press.
- Denzin, N.K. & Lincoln, Y.S. (2000) *Handbook of Qualitative Research*. 2nd edn. Thousand Oaks: Sage.
- Erstad, O. (2004) *PILOT for skoleutvikling. Samlerapport fra forskningen 2000-2003* [PILOTS for school development. Final report from the research period 2000-2003]. ITU Skriftserie. Report 28. Oslo: Unipub (in Norwegian).
- Firestone, W.A. (1993) Alternative Arguments for Generalizing from Data as Applied to Qualitative Research, *Educational Researcher*, 22(4), 16-23.
- Fornyings- og administrasjonsdepartementet (FAD) [Ministry of Government Administration and Reform] (2007) *Bredbånd. Dekningsanalyse 2007* [Broadband. Coverage analysis 2007]. Oslo: Teleplan (in Norwegian).
- Fullan, M. (1991) *The New Meaning of Educational Change*. London: Routledge Falmer.
- Gans, H.J. (1982) The Participant Observer as Human Being: observations on the personal aspect of fieldwork, in R.G. Burgess (Ed.) *Field Research: a sourcebook and field manual*. London: Allen & Unwin.
- Geertz, C. (1973) *The Interpretation of Cultures: selected essays*. New York: Basic Books.
- Goodson, I. (1999) Professional Knowledge and the Teacher's Life and Work, in C. Day (Ed.) *Life and Work of Teachers: international perspectives in changing times*. London: Falmer Press.

- Handal, G. & Lauvås, P. (2000) *Veiledning og praktisk yrkesteori* [Supervision and practical occupational theory]. Oslo: Cappelen (in Norwegian).
- Hargreaves, A. (1993) Individualism and Individuality: reinterpreting the teacher culture, in J.W. Little & M.W. McLaughlin (Eds) *Teachers' Work: individuals, colleagues, and contexts*, 51-77. New York: Teachers College Press.
- Haug, P. (2004) *Evauering av Reform 97* [Evaluation of Reform 97]. Oslo: Norges Forskningsråd (in Norwegian).
- Haug, P. (2005) Er det å forske på praksis viktig for praksisfeltet? [Is research on practice important to the practice field?]. *Konferanserapport FOU i praksis 2005* [Conference Report from Research and Development in Practice 2005], 125-137. Trondheim: PPU serien, NTNU (in Norwegian).
- Higgins, S. & Moseley, D. (2001) Teachers' Thinking about Information and Communications Technology and Learning: beliefs and outcomes, *Teacher Development*, 5(2), 191-208.
<http://dx.doi.org/10.1080/13664530100200138>
- Hughes, J. (2005) The Role of Teacher Knowledge and Learning Experiences in Forming Technology-Integrated Pedagogy, *Journal of Technology and Teacher Education*, 13(2), 277-302.
- Keating, T. & Evans, E. (2001) Three Computers in the Back of the Classroom: pre-service teachers' conceptions of technology integration. Paper presented at the annual meeting of the American Educational Research Association, Seattle, WA.
- Klette, K. (2003) Lærereens klasseromsarbeid; Interaksjons og arbeidsformer i norske klasserom etter reform 97 [Teachers' work in the classroom; forms of interaction and work in Norwegian classrooms after the Reform of 1997], in K. Klette (Ed.) *Klasserommets praksisformer etter Reform 97* [The practice in classrooms after Reform 97]. Oslo: UniPub Forlag (in Norwegian).
- Kløvstad, V., Erstad, O., Kristiansen, T. & Soby, M. (2005) *ITU Monitor 2005. Skolens digitale tilstand 2005* [The digital conditions in school 2005]. Oslo: Universitetsforlaget (in Norwegian).
- Koehler, M.J., Mishra, P. & Yahya, K. (2007) Tracing the Development of Teacher Knowledge in a Design Seminar: integrating content, pedagogy and technology, *Computers & Education*, 49(3), 740-762.
<http://dx.doi.org/10.1016/j.compedu.2005.11.012>
- Krumsvik, R. (2006a) *ICT in Lower Secondary School: ICT-initiated school development in lower secondary school*. Phd Thesis, University of Bergen. Bergen: Allkopi.
- Krumsvik, R. (2006b) The Digital Challenges of School and Teacher Education: some urgent questions and the search for answers, *Education and Information Technologies*, 3 & 4(11), 239-256.
- Krumsvik, R. (2007a) Developing a New Model of Digital Literacy for In-Service Teachers (work in progress, unpublished manuscript).
- Krumsvik, R. (2007b) *Skulen og den digitale læringsrevolusjonen* [The school and the digital learning revolution]. Oslo. Universitetsforlaget (in Norwegian).
- Kunnskapsdepartementet (KD) [Ministry of Knowledge] (2006) Kunnskapsløftet. Læreplan for den 13-årige grunnsopplæringa [The knowledge promotion. The new national curriculum].
<http://odin.dep.no/kd/english/topics/knowledgepromotion/bn.html> (accessed 23 October 2007).
- Kvale, S. (2001) *Det kvalitative forskningsintervju* [The qualitative research interview]. Oslo: Ad Notam Gyldendal (in Norwegian).
- Latour, B. (1999) *Pandora's Hope*. Cambridge, MA: Harvard University Press.
- Lundeberg, M.A., Bergland, M., Klyczek, K. & Hoffman, D. (2003) Using Action Research to Develop Preservice Teachers' Beliefs, Knowledge and Confidence about Technology, *Journal of Interactive Online Learning*, 1(4). <http://ncolr.uidaho.com/jiol/archives/2003/spring/toc.asp> (accessed 29 June 2004).
- Margerum-Leys, J. & Marx, R. (2002) Teacher Knowledge of Educational Technology: a study of student teacher/mentor teacher pairs, *Journal of Educational Computing Research*, 26(4), 427-462.
<http://dx.doi.org/10.2190/JXBR-2G0G-1E4T-7T4M>
- McTaggart, R (1991) Principles for Participatory Action Research, *Adult Education Quarterly*, 41(3), 168-187.
<http://dx.doi.org/10.1177/0001848191041003003>
- Merriam, S. (1998) *Qualitative Research and Case Study Applications in Education*. San Francisco: Jossey-Bass.
- Mishra, P. & Koehler, M.J. (2006) Technological Pedagogical Content Knowledge: a new framework for teacher knowledge, *Teachers College Record*, 108(6), 1017-1054.
<http://dx.doi.org/10.1111/j.1467-9620.2006.00684.x>
- Neiss, M.L. (2005) Preparing Teachers to Teach Science and Mathematics with Technology: developing a technology pedagogical content knowledge, *Teaching and Teacher Education*, 21(5), 509-523.
<http://dx.doi.org/10.1016/j.tate.2005.03.006>

- Organisation for Economic co-Operation and Development (OECD)(2004) *OECD Information Technology Outlook 2004*. <http://www.oecd.org/dataoecd/22/18/37620123.pdf> (accessed 9 February 2007).
- Patton, M.Q. (1990) *Qualitative Evaluation Methods*. 2nd edn. Thousand Oaks: Sage.
- Polanyi, M. (1967) *The Tacit Dimension*. New York: Anchor Books.
- Project Plan PILOT ved Dalane Videregående Skole [Project Plan at Dalane Upper Secondary School]. http://www.dalane.vgs.no/arkiv/framoe84/PILOT/pilot_prosjektplan2000-1-3b.doc (accessed 1 October 2007) (in Norwegian).
- Sarason, S.B. (1984) If it Can Be Studied or Developed, Should it Be? *American Psychologist*, 39, 477-485. <http://dx.doi.org/10.1037/0003-066X.39.5.477>
- Sarason, S.B. (1993) *The Predictable Failure of Educational Reform: can we change course before it's too late?* San Francisco: Jossey-Bass.
- Schofield, J. (1990) Increasing the Generalizability of Qualitative Research, in E. Eisner & A. Peshkin (Eds) *Quality Inquiry in Education*, 201-232. New York: Teachers College Press.
- Schön, D. (1983) *The Reflective Practitioner: how professionals think in action*. Aldershot: Ashgate.
- Shulman, L. (1986) Those Who Understand: knowledge growth in teaching, *Educational Researcher*, 15(2), 4-14.
- Shulman, L. (1987) Knowledge and Teaching: foundations of the new reform, in S.M. Wilson (Eds) (2004) *The Wisdom of Practice: essays on teaching, learning, and learning to teach*, 219-248. San Francisco: Jossey-Bass.
- Shulman, L. (1997) Professional Development: learning from experience, in S.M. Wilson (Ed.) (2004) *The Wisdom of Practice: essays on teaching, learning, and learning to teach*, 503-520. San Francisco: Jossey-Bass.
- Somekh, B., Underwood, J., Convery, A., et al (2006) *Evaluation of the ICT Test Bed Project*. Nottingham: Nottingham Trent University. http://www.evaluation.icctestbed.org.uk/files/ict_test_bed_evaluation_2005.pdf (accessed 1 October 2007).
- Utdanningsdirektoratet [The Norwegian Directorate for Education and Training] (2007) *Utstyrs- og driftssituasjonen i grunnskolingen 2006-2007* [Equipment and technical management in primary and secondary education and training]. Oslo: The Norwegian Directorate for Education and Training (in Norwegian).
- Vaage, O.F. (2005) *Norsk Mediebarometer 2004* [The Norwegian Mediabarometer]. Oslo: Statistisk Sentralbyrå. <http://www.ssb.no/emner/07/02/30/medie/arkiv/sa68/> (accessed 9 February 2007) (in Norwegian).
- Vaage, O.F. (2007) Stadig mer tid foran skjermen [Continuous more time in front of the screen]. *Samfunnspeilet*, 4 (in Norwegian).
- Walker, R. (1980) The Conduct of Educational Case Studies: ethics, theory and procedures, in W.B. Dockerrell & D. Hamilton (Eds) *Rethinking Educational Research*. London: Hodder & Stoughton.
- Watson, D.M. (2003) The Teacher – the forgotten stakeholder? in C. Dowling & K.W. Lai (Eds) *ICT and The Teacher of the Future*, 29-38. New York: Kluwer.
- Yin, R.K. (1994) *Case Study Research: design and methods*. Beverly Hills: Sage.
- Zhao, Y. (Ed.) (2003) *What Teachers Should Know about Technology: perspectives and practices*. Greenwich, CT: Information Age.

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