

Understanding the relationship between ICT and education means exploring innovation and change

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Abstract This paper sets the debates of the other papers in the context of a benchmark in time that is after four decades of deliberations about the relationship between ICT and education. The environment for and deliberations about this relationship has been one of rapid change in perspectives, most characterised as a shift of focus from the technology to learning. While contemplating the future however, a number of enduring issues remain, including understanding how learning occurs, learning with or about the technology, and the role of the teacher and professional development. The papers address these issues, as well as exploring national policies and software learning environments; all reflect on the growing complexity of the situation and the conundrum of failure to achieve ‘lift-off.’ Key phrases for debates in the future include lifelong learning, the commonplace of ICT in society, the digital world of the young, and the digital ethical dilemmas. In addition I suggest that the key word of change could be paid more attention.

Keywords Digital and educational environments · Learning · Teachers · Theories and models of change

1 Introduction

In 2006, the International Federation of Information Processing (IFIP) working group on *ICT and informatics in secondary education* (WG 3.1) celebrated its 40th birthday. Established in 1996 as the first working group of the IFIP Technical Committee 3 on Education, WG 3.1 could be said to be the forerunner of the subsequent six working groups and one special interest group. In this sense it could symbolically represent the active work of TC 3. To have explored the relationship between computers and education for 40 years was clearly a cause for celebration, and what better way than to mount a working conference. But an event that simply reflected its past was neither the style nor wish of the working group. Instead it combined with its partners in Working Group 3.5 (ICT and

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informatics in elementary education), Working Group 3.3 (Research on educational applications of information technologies), and the special interest group on lifelong learning, to discuss “Imagining the future for ICT and education” during 5 days in June 2006 at Alesund, Norway.

The papers in this special issue are a selection of 14 taken from those presented at the conference. They have been chosen in part to represent the issues debated. Of course they cannot fully represent the range or flavour of the many sessions, discussions, panels, workshops, focus groups and informal conversations. But these papers do contribute by reporting on research and characterising the state of some current issues, concerns and dilemmas in the community that explores the relationship between information and communication technologies and education in a world now dominated by the digital environment.

My intention in this paper is to introduce these papers that make up this special issue. In addition it is my aim to explore briefly how we have travelled to this position, to note enduring issues and present possible themes for future debates. In effect I hope to set the opinions of the authors within the context of the questions that I consider have exercised this community for some time, and also to suggest some underlying conceptual frameworks within which the future may be debated.

2 From the technology to the learner

When opening the conference, Sindre Rosvik, co-chair of the conference and the chair of WG 3.5, alerted us to the changing nature of the debates in the previous 20 years, and illustrated that the focus today in 2006 is on learning and the learner. In 1985 having micro-computers in schools was still relatively novel, with much discussion on the development of the hardware itself, educational software, teaching computer science, teaching teachers to write their own programmes in BASIC, the then excitement of Logo. Increased memory was promised, and the new icon-based user interface from Mac had just arrived. Educational concerns included the design of in-service and pre-service training course for teachers, the location of micros, and developing education software packages, most of which were to support the learning science of mathematics. Many addressed the further and higher education environment, but some were beginning to look at the primary/elementary years. What form should the computer science curricula take in schools? Which subjects benefited from computer assisted learning? The location of micros in schools was an issue—stand-alones or networked rooms?—while the possibility of them supporting distance education was under exploration. The tone of many papers was positive and forward looking with expectations that once enough software was developed and teachers trained, using computers would be a relatively normal in educational institutions (Duncan & Harris, 1985).

Twenty years later the landscape is dominated by PCs and laptops, mobile technology, the Internet and Worldwide Web—a digital world of interconnectivity. The hardware is relatively cheap, with virtually unlimited memory, power and connectivity devices. General-purpose business packages (word processing, data-handling, spreadsheets and presentation) are ubiquitous, as is a relatively common user interface. Graphics, still and moving images, and music are common features, while interconnectivity with mobile communication and its voice technology has altered the voice recognition issue. The pace and range of information and communication technological capability has outstripped our earlier imaginings, but also moved in less anticipated directions. The technology is everywhere—in the home, workplace and community—and no longer the preserve of

education and business. ICTs are now integrated into the operation of much that makes society function, from government offices and state business, health and other services, to commerce and personal shopping. Differential access within and between communities, within and between countries and regions of the world, has coined the phrase the digital divide.

In many parts of the world, computers and a number of related devices are readily available in schools, although it is salutary to remember those areas where this is not the case (WCCE, 2005). In schools computer science courses are more often referred to now as Informatics or Information Technology, and many are concerned to provide a basic understanding of the concepts of Information Technology rather than teach algorithms and programming. There has been a shift in emphasis from teaching to learning, with substantial debate on the role of the teacher in facilitating learning, as well as attention for a period on individual and independent learning. Communication and collaboration, among and between both learners and teachers is a major concern, encompassing synchronous and asynchronous online facilities. Enabling and indeed allowing learners to set their agendas, to explore the nature of information, and the nature of knowledge are part of the discourse. Nevertheless concerns for the professional development of teachers remain. An increasing variety of national policy initiatives, programmes and projects are reported, although evaluation studies indicate that their effectiveness can be disappointing. But there can be no doubt that educational concerns in this digital environment have broadened and deepened (Dowling & Lai, 2003; Marshall & Katz, 2003; Somekh, 2005; Taylor & Hogenbirk, 2001; Watson & Andersen, 2002; Watson & Downes, 2000; WCCE, 2005).

The topics of all our TC 3 conferences publications and reports since 1985, which can be found on the IFIP website (IFIP), illustrate the shift of concerns from the technology, its environment and teaching with ICT to a focus on the learner, both within and beyond school institutions. Thus from integrating information technology into education to networking the learner; from informatics and the teaching of mathematics to information and communication technology and the teacher of the future, and from a computer for each student to learning for the twenty-first century: what really matters? In the last decade it has also become apparent that the educational agenda for ICT in schools can no longer be considered in isolation.

I would argue however that during this period of rapid change, some issues remain both substantial and enduring.

3 Enduring issues

I will characterise these issues as understanding learning, learning about or learning with, the problematic of teachers, and a technocentric enthusiasm.

3.1 Understanding learning

Serious attention in ICT studies has been paid to the theories of learning and how they may be supported by ICT. A shift in perspective has emerged that instead of learning from the use of software, students learned with it, and the computer is referred to as a “mindtool” (Jonassen, 2000) in its own right. Applications became categorised by the nature of constructive learning they enabled. Thus for instance applications could be categorised as semantic organisers, dynamic modelling tools and knowledge construction tools. Such tools would represent cognitive scaffolds, engaging learners in critical thinking. Then situated

learning (Lave & Wenger, 1991), communities of practice, (Wenger, 1998) and activity theory (Engstrom, 1995) that focus on learning as a social activity, are underpinning much of the more recent studies. A focus on learning as part of everyday life, with fluid learning communities, which involve participation, collaboration and dialogue, and the construction and critical use of intelligent tools and artefacts, is attractive to support alternative frames of schooling and lifelong learning with ICT. Activity theory is equally attractive for ICT research as tools provide both a basis for learning and understanding its use.

Situated cognition, collaborative learning, and activity theory have increasingly entered the language to support the use of ICT for learning. Despite many studies undertaken, however, it is not clear what learning gains can be explicitly associated with using ICT, and such lack of clarity remains problematic. Cox and Marshall (2005) state that despite a plethora of studies on the effects of ICT in education, methodological problems mean that results are not reliable, and those that are tend to be inconclusive. Further, results often neither isolate the specific effects of use, nor confirm that that any effect was sustainable. They report that the most robust evidence of ICT use to enhance students' learning comes from studies that focussed only on particular uses of ICT. So the exploration of learning with, by or through the technology remains problematic.

3.2 Learning about or learning with?

Is the educational focus on learning about or learning with computers? The debate is not as simple as this—but rather encompasses both the relative balance of resources made available, the relative weight given to each of the two perspectives, and the thorny question of 'learning ICT skills.' We have not yet moved on from some ICT skill learning happening in isolation from 'real' tasks, that might have an end purpose and learning benefit in their own right. Today, many young will learn basic digital literacies by exploration, trial and error. I am not aware of anyone in schools teaching the young how to text message or adopt digital shorthand. So I could argue that in one sense education is still too engaged with learning about computers as a tool and the skills needed for operation; that many of the tasks for which ICT is used still support 'lower order thinking'; and that greater focus could be placed more complex, context-driven tasks, and on the pedagogy and knowledge contexts. The goal may be integration, a seamless link between the technology and learning, understanding and applying, but the reality still falls far short.

Part of this issue therefore encompasses the question of the curriculum and pedagogy vs the hegemony of general-purpose packages. It is sad truth that the number of educational simulations under development has declined drastically in the last 20 years. Simulations, often with a role-playing element, went to the heart of curriculum focus and teacher engagement. General-purpose packages require the subject or curriculum specific element to be incorporated, and while the data is more readily available for information processing, the models upon which simulations are based are not.

In parallel but related has been a substantial shift in the computer science, or Informatics curriculum. No longer simply focussed only potential undergraduate students, it has concerns for future employees in business and industry. And because of the nature of the technology and large special and general purpose packages, the industry needs fewer people with substantial programming skills, but more who understand the concepts on which ICT is based, who can engage in problem-solving, who can work in collaborative teams (Schubert & Taylor, 2004; Schwill, 1997). In this sense, and possibly ironically, Informatics may provide us with an example of a subject in schools that is embracing a number of aspects the nature of learning, including the development of cognitive tools, exploring

conceptual knowledge and social responsibility that are desirable and extolled across the school curriculum.

3.3 The problematic of the teacher

Is the teacher a catalyst or inhibitor, an innovator or conservator of the status quo? Will the substantial investment in teacher education and professional development shift this conundrum? Carnell (2000) suggests that continual professional development has shifted from a previous, more functionalist or professional view towards a learner-centred stance. Then Day and Sachs (2004) focus on the reasons why teachers may want and need to acquire knowledge and the locus of its application. And yet there is an increasing political component to professional development where the perceived need for change, can force a functionalist skills-based structure to ensure ‘delivery’ of policy objectives (Carr, 2000; Guskey & Huberman, 1995; Hargreaves, 1994). It would seem that this is particularly so in association with new technologies, and explains some of the dilemmas surrounding the characterisation of teachers. Fullan (2001) has proposed that the role of facilitators in professional development/training plays an important part in professional development and change; this might be especially relevant in environments where there has been little tradition or demand for professional development in the past. Facilitators however can pay too much attention to analysis and recommendations and not enough to the complexity of translating these into actions.

Central to teachers’ reactions to any suggested change in their established practice is the issue of whether it is practical. Brown and MacIntyre (1993), state that the teacher must be convinced of both of the need for change, and also that the means whereby change can be incorporated into their practice are available. Olson (1992) concurs but also notes that there is an essential elasticity to the professional practice of teachers in classrooms that can and does accommodate change. Part of that elasticity also reflects Erault’s (1994) notion that teaching is a performance profession. And Goodson and Hargreaves (1996) note that professional development must allow for reflection on the value and wealth of the teachers’ own experiential knowledge. Beynon and Mackay (1992, 1993) reflect that introducing ICTs into teaching create a number of tensions that professional development does not necessarily resolve. I have myself noted the dichotomy of purpose in rationales for using technology that leaves teachers unconvinced (Watson, 2001); and that those who don’t use ICT do so because it resonates with their personal beliefs and professional philosophy of teaching (Watson, 1993). And yet much professional development for using ICT in education leaves the participants feeling that training has been done to them rather than with them (Burstow, 2006). Professional development is a complex process.

Research such as that reported by Gross, Giacquinta, and Berstein (1971) indicated that there was no resistance to planned change on the part of teachers. On the contrary, they were receptive to educational innovation, but the strategies for implementation were deficient in two respects—failure to identify and bring into the open various difficulties teachers were liable to encounter in their implementation effects, and failure to establish and use feedback mechanisms to uncover barriers that arose during the period of attempted implementation. More recent work involving ICT and professional development, seen in the papers of the last three world conferences (Tinsley & van Weert, 1995; Watson & Andersen, 2002; WCCE, 2005) use the notion of affordances, activity and transformation theories as means to explain and explore how teachers may negotiate organisational barriers. So in some senses the discourse is shifting from the problematic of teachers to the complexity of organisational barriers and the means for teachers to relate and transform

their tacit and professional knowledge with the opportunities and demands presented by ICT.

3.4 A technocentric enthusiasm

It is clear that some of the concerns addressed above have been in part generated by an enthusiasm for the technology and its attributes. Many would say this is a problem, suggesting that unabashed enthusiasm of authors such as Papert (1980) and Gates (1996) has presented an imagery of new positive change and renewal for learning. Mackenzie and Wajcman (1985), Turkle (1996) and Finnegan, Salaman, and Thompson (1991) among others suggest that such enthusiasm causes confused notions of a technocentric society. They remind us that the technology is not superordinate to society, with a separate will of its own, but merely a construct of society as is any other technology, and its use will be determined in part by society and not the technology itself. We have witnessed this in the last decade with the unanticipated and rapid adoption of the mobile phone. Evaluation studies by Cuban (1986, 2001) suggest that unreflective and unabashed enthusiasm about the necessarily transformative nature of new information technologies is both naïve and historically unfounded. He has written that in the battle between classrooms and computers, the classroom wins. Indeed Miller and Olson (1994) have pointed out that:

the history of innovation in education should teach us to be cautious about predictions associated with new technologies. However there is something about computers that negate this caution. Whenever computers are discussed, words such as revolution, powerful ideas, microworlds, and student empowerment occur frequently.

Such enthusiasm, together with an economic agenda, has triggered a substantial interest by governments and international agencies in the promotion of the use of the technologies in education, with the associated rhetoric for the significance of the information society and globalisation. The problem is reflected in more recent national and international studies, such as those of SITES (Kozma, 2003) and PISA (OECD, 2006) that indicate the difference between the rhetoric for change using ICT and the reality of the actual use in education. There remains therefore an interesting tension between the necessity of the enthusiasm of innovators, and the reality of implementation for all.

3.5 Social and ethical issues

Finally, an area which is perceived as significant in the international arena (van Weert and Munro, 2003; van Weert, 2005) but which remains poorly represented in the schools agenda. Parents and teachers are often aware of the dangers of net ‘grooming’ and pornography, but responsible use of the technology means people have to know and understand a variety of issues that the technology itself brings. These include questions of legality and veracity, security and surveillance, ethical dilemmas, and power. Personal and collective responsibilities will only develop in association with discussion and debate, and understanding that the digital world exists within the legal and social norms that have developed over centuries. Such debates should occur in schools.

These enduring issues reflect my views on where our debates now lie. And while there is an acknowledgement that change is happening, it is not always in the direction or as enduring as anticipated. After 40 years of endeavour, we are at a stage where the preparations for take off are now more clearly understood, but we are still attempting to find better triggers or environments for the potential to flourish. A key feature for me in 2006 is the recognition of

complex and multifaceted relationship between ICT and education. The papers introduced below reflect on these.

4 A complex and multifaceted relationship

4.1 Learning challenges

In education in the twenty-first century: new professionalism in lifelong learning, knowledge development and knowledge sharing, Tom van Weert explores the forms of education that might emerge to serve a knowledge society in which ICT is omnipresent and ubiquitous. He proposes that such a society places three demands upon its citizens and workers: lifelong learning which is learner-centred and based on learning competencies acquired through interaction; knowledge development through practical research; and knowledge sharing as a necessary condition. He further proposes that knowledge is the only resource, which grows through sharing, which will be facilitated through enquiring communities of practice.

Such a scenario would have profound consequences for education and its professionals. Education will find itself in a continuous process of change, and it will need to adapt as a learning organisation. He suggests this will also have a profound effect upon the structures and timelines of research. Included in this, he proposes, is a change for teaching professionals, who will, as ‘knowledge workers’ need to engage in practical research, knowledge sharing and critical reflection.

Rune Krumsvik provides a related argument as he discusses how the digital revolution creates new possibilities, dilemmas and challenges for school and teacher education in our contemporary society. Does the new, converging internet-based technology create fertile ground for the mandatory digital literacy in Norwegian schools? And if so, what happens to how teachers teach and learners learn? In *The Digital Challenges of School and Teacher Education in Norway* he reports that it is already known there is a gap between policy intentions and practice with respect to the use of ICT in schools and teacher education, in part because school organisations are slow adapters to change.

The skills and digital competence of ‘screenagers’ (lower secondary school pupils), create further dilemmas explored in the literature, even in a country which has relatively little digital divides and a high technological density. Some though not all of their usage is not necessarily related to higher order thinking. This, the author believes is compounded if the emphasis on digital literacy places an undue emphasis on skills which are assessed traditionally. He proposes that a new digital epistemology is required for education, with a parallel impact on pedagogy. All this challenges the teacher’s role. So instead of maintaining a rhetoric-based on either technologies’ excellence or profound scepticism, a new third way is required based on hands-on experiences and new knowledge.

4.2 Teacher’s professional development

Focusing further on teachers, Yvonne Buettner reports on the conundrum of educating teachers to use ICT for teaching and learning. In *Teaching Teachers to Teach ICT Integration* she describes a problem familiar to many countries, that after 20 years of computers in schools and efforts to integrate ICT into teaching, the use of computers in classrooms is still low. And this is despite the fact that computers are now relatively cheap and ubiquitous, and that software is much easier to use. One problem she identifies is that

with each new stage in development over the last 20 years—from programming, user friendly applications, authoring programmes, to browsers and the web, and now virtual platforms for cooperation and sharing—teachers have had to learn new things and handle new teaching skills. Indeed, there are now a range of media competencies teachers must have to maximise the value of ICT learning in classrooms.

The author reports on one solution tried in Switzerland, a nationally funded project based on three topics—teacher education, building up an infrastructure and developing content—designed to enhance the ICT in education and thus facilitate a Swiss ‘information society.’ In northwest Switzerland, they focused on enabling teachers to become ‘ICT course instructors’ and this cascade their theoretical and practical experiences through the school and adult education systems. She identifies a number of ambient conditions that this project identified as being essential for change to have a chance to flourish—including assumptions that using ICT in education is a lifelong learning experience, time for study and reflection, the support of principals, appropriate learning platforms, and the development of networks and openness about issues among all involved. There was also a real concern that without stimulation and coordination from the project, it was less sure how the momentum of change could be maintained. An evaluation is now underway to assess the effects of the project in increasing the amount of ICI use in schools.

Then Nicki Carr and Dianne Chambers, in their paper *Are We There Yet? The Rocky Road to Online Communities of Teachers*, focus on teacher professional development. They reflect on the fact that the literature suggests that the most effective forms of teacher professional learning include collegial sharing and reflection about practice. This encourages self-reflection and supports risk taking and the struggle entailed in transforming practice. They report that ICTs are claimed to have the potential to foster the conditions in which collegiate, reflective-based teacher professional learning can occur though on-line environments and related networks. In particular the asynchronous virtual communities are thought to be more reflective than traditional environments. Much investment is underway in a number of countries to develop on-line communities of practice among teachers.

The authors examined one such network funded by the Australian government. They conducted interviews with participants in the project, selected on the basis of their level of contribution to the on-line community. From these they identified a range of factors, some organisational and others personal that appeared to act as key barriers to teacher participation. In particular they report that two issues emerged common to both these organisational and personal factors—that is a general lack of either reflective culture or an on-line culture. They propose that this suggests that the potential for online communities to foster professional learning is there, but that attention needs to be paid to building positive reflective and online cultures as a starting point towards ensuring that organisational and personal barriers may be overcome.

Matthew Pearson and Steven Naylor report on a project investigating innovative practice using ICT in secondary schools. In *Changing Contexts: Teacher Professional Development and ICT Pedagogy* they interrogate the meaning of the word “innovative” when applied to education and examine how various meanings are operational. They further argue that clarification of the meaning of ICT and of innovation as it relates to ICT and schooling is needed in order to identify genuinely new and exciting practices. In particular as understanding is needed of both technological contexts and the concept of the school as a dynamic learning community.

Their study was undertaken through a series of case studies that set out to ‘map the field.’ From these snapshots of local practice they selected elements that were useful in the

production of vignettes, or telling cases. Three key themes emerged from the analysis of data. The significance of the public face of a schools, that it needs to stage-manage and present; a tension between the re-tooling with new networks and the reforming pedagogic agendas they are meant to herald; and the transformation of teachers identities and normal work-based activities. The authors point to the potential dissonances between a school's collective efforts at introducing innovative practices and actual implementation at classroom level. This difficulty is compounded by the multi-faceted nature of modern digital technology and the various ways it can be used to support educational practices.

The next paper *Educational Transformation: Is it, Like Beauty, in the Eye of the Beholder, or Will We Know It When We See It?* explores meanings behind the word “transformation.” This term is often used in connection with modern educational change, particularly when such change involves new technologies. But the author, Tony Fisher, here suggests that on closer examination, transformation is used as a descriptor of change in ways that are multifarious, inconsistent, and sometimes unwarranted. In effect, although the word is redolent with fundamental changes to the structures of teaching and learning, the rhetoric appears to associate technology itself as an agency for change—and thus technological determinism. The author prefers to consider activity theory as a basis for exploring then notion of educational transformation, which allows for the inclusion on the role of teachers as social agents in the process.

Since the concept of transformation has wide currency, especially in policy documents, it is important to understand how intertwined this is with a technological determinism upon which governments build expectations, and explains the way computers are ‘sold’ to society. The problem for Fisher is that this leaves largely invisible the emotional and intellectual work that teachers must undertake in order to realise the claimed potential improvements and transformations. He continues by dissecting the introduction of interactive whiteboards as part of this social shaping of the technology. He proposed that if schools were acknowledged as activity systems, then teachers might better understand their engagements with the digital technologies to support and extend the learning process. In essence, Fisher argues that the language associated with the technologies places undue emphasis on the technology and not enough on human agency.

4.3 Informatics—separate or integrated concerns?

Moving to the Informatics curriculum, but within concerns for pedagogy, the paper *Informatics Systems Comprehension: A Learner-Centred Cognitive Approach to Networked Thinking* exemplifies the debate on the nature and purpose of the curriculum in informatics in secondary education that has flourished in the last decade. In essence Peer Stechert argues that learners have to create a sustainable cognitive model of a computer to demystify an information system. In order to achieve this, students need to know networked ideas to help them develop a cognitive approach to information systems.

The author supports the notion that the fundamental idea of an information system is provided by three foci—that is language, algorithmisation and structure dissection. Yet these are often treated as separate entities without substantial attention to interconnectivity. And building on the earlier ideas of the value of exploration models as a basis to support learning and teaching, he describes the development of an exploration module to introduce design patterns with an emphasis on systems comprehension, and specifically for networked fundamental ideas. Also embedded here the ongoing development of curriculum modules, based upon ideas test-bedded in context, leading to exposure and discussion with

a wider international community to explore and collect evaluation during the application phase of development. Throughout the author emphasises that there is a strong cognitive quality of the design patterns, which are in turn complex enough to be seen as system representations forming sub-systems combined with other design patterns. The next stage will be to explore the module with informatics trainee teachers.

Then Johannes Magenheimer and Carsten Schulte provide a different approach that reflects the substantial amount of thought that is underlying both the structure and purpose behind an informatics curriculum for schools. In *Social, Ethical and Technical Issues in Informatics—An Integrated Approach* they develop the context of socio-technical informatics systems. Their purpose is to provide a didactic approach that demonstrates and underpins the links between computational issues and their close relation to social and ethical issues. They point out that there has been an increasing identification of the ethical and social issues which surround computers and their use, as topics essential in Informatics and Computer Science curricula. But they also note that in reality these topics tend to be treated as discrete entities and not integrated into the fundamental modules of most courses.

In essence the authors argue that software development, an essential subject in the Computer Science/Informatics curriculum, should be regarded as more than a technical process. It must embrace in full the socio-technical scenario, not simply with respect to the human computer interface, but with an acknowledgment of the interaction between people using the system as well as the interface between peoples and the system. In this sense they define software as more than a technical artefact, and propose that the intertwining of social and technical issues is closely connected to the development process, and attention to the social aspects will strengthen the value of the software. They provide illustrations to underpin their ideas. These go some way towards a more integrative approach—not simply to ensure that social and ethical issues are covered, but also, as with Stechert, to underpin the importance of understanding cognition and the issues in association with learning and teaching.

4.4 Software environments

The next paper considers the development of software environments. Marta Turcsanyi-Szabo, Andrea Bedo and Zsusa Pluhar, in their paper *Case Study of Team Challenge Games—e-PBL Revisited*, explore the challenges of developing the key competencies individuals need to acquire in today's complex world. One in particular is that of being reflective problem solvers. Recent PISA studies however have indicated that only one in five 15-year olds can be so classified. Clearly this area needs to be tackled. This is made even more compelling when it is clear that the move predicted move of schools from instructional institutions to learning ones has so far not been realised.

The authors characterise problem-based learning (PBL) as both a curriculum and a process. They describe a series of team challenge games designed as part of the Informatics teacher training programme in ELTE University in Hungary. These are complex, real-life contextualised problems, designed around puzzles or riddles, and that urge school informatics pupils to search the internet and other sources, including advice from teachers families and friends, to find solutions. The games were designed to ensure that teams of students were posed problems that could not be solved by, for instance, one teacher alone, thus forcing them into a collaborative activity. The effectiveness of the activity was evaluated though the four main groups of actors involved—the trainee teachers, the schoolteachers of the classes engaged, and the teams of students, and the members of the development team. The teachers using the games reported changes in their pupils thinking strategic and the valuable benefit of collaboration and

the development of group identities. Interestingly, little evaluative data emerged, in part the authors report because of a ‘challenge fever’ leading to a lack of rigour in exploring the effects rather than stimulating them. Nevertheless the group consider that the use of mindmaps by students enable teachers and the team to chart the processes. Although there was some evidence that pupils did not necessarily progress through nodes, it was considered that this team challenge approach has potential for e-PBL.

Rune Baggetun and Stig Mjelsted describe a novel perspective of integrating digital media in education. In *E-LOGG: Facilitating Ownership and Openness in Virtual Learning Environments* they report that one type of use of ICT that has been growing rapidly in the Norwegian school sector is supported by Learning Management Systems (LMS). As an alternative, and as part of a research and development project, they developed and tested eLogg. This was built on different assumptions and ideas about how to facilitate learning and communication in school settings compared with a typical LMS. The development of eLogg was strongly influenced by popular technologies such as weblogs and wikis.

As part of their formative development, eLogg was tested in various schools settings, where they analysed the various ‘products’ of use by teachers and pupils, including texts, posts, projects and media files, and observed classrooms. In their analysis of pupil use they identify five activity types used by the pupils—peer conversations, resource sharing, lurking, project work and assignments. From interviews with teachers and reading their written “reflective notes,” they noted four reactions—scepticism about openness, positive attitudes to the system and experience, the notion of it as a nice supplement, and a reaction to organisational issues. Most telling is their report on a control analysis of an LMS case study, which appeared to facilitate little interaction between pupils, and from which the authors summarise major differences between eLogg and LMS. In effect the authors highlight that openness and ownership are important aspects of supporting learning though digital technologies. Thus they conclude that there is no such thing as pedagogically neutral technology. Rather technologies come with inscriptions and perspectives on learning, and analysis of the affordances systems can offer is an essential component for an environment for pupils to be able to take ownership of their learning.

In their keynote paper, Ivan Kalas and Michal Winszer explore the notion of collaborative learning the development of educational programming tools, such as Imagine and SuperLogo, to support the learning process. The aim of the work reported in *Building Interfaces for Online Collaborative Learning*, is to provide users, from developers to young children, with new and powerful options to foster learning by exploring and developing. Thus the authors explain why Imagine is equipped with means of building objects and their behaviours in incremental loops, with parallel independent processes, event-driven programming and complex yet intuitive support for developing on-line environments for collaborative learning.

The authors place their collaborative microworlds alongside other related interfaces in order to distinguish theirs from others and highlight their unique features to inspire on-line collaboration. In particular they distinguish between co-present and collaborative learning in order to highlight the particular characteristics of the collaborative interfaces they are developing. They are attracted to microworlds because they concur that such environments focus on immersive learning and can sensitively tune to a person’s cognitive and motivational states. When these are combined with network functionality, they provide a platform for on-line collaboration. They describe the dimensions of such a system, and focus on the particular challenge of sharing and activity. The teamwork described in this paper has produced nine experimental environments for children, aged 10 to 18 years, to use. Each

focuses on certain aspects of collaboration. From these they identify the critical factors of efficient collaboration, and are now seeking partners in schools to explore the potential for integration of these environments into every day learning in schools.

4.5 National policies

Sarah Younie probes documentary and research evidence about the implementation process of national initiatives with regard to ICT in education. In her paper, *Implementing Government Policy on ICT in Education: Lessons Learnt*, she reports that despite a range of policy initiatives in the UK since the 1980s, it became clear by the turn of the century that a gap was emerging between the legislative requirements and the reality of what was happening in schools. A number of evidenced-based evaluation reports were produced that indicated five critical area relating to management, funding, technology procurement, ICT training and the impact on pedagogy.

Possibly the most significant finding was that too many different government agencies were involved in initiatives, each with different management styles and even goals for achievement. Operational relationships between agencies, and their levels of ICT awareness and knowledge, were found wanting. In part because of multi-agency, funding was not uniformly allocated, leading to instability in the procurement, installation and sustainability of the technology. A national teacher training strategy did not allow enough for local context. And so, the impact of ICT initiatives on teachers' classroom use of ICT has remained problematic.

The author argues that in part these problems are caused buy a failure of government to recognise the complexity of the implementation process—both at the macro level, but also at the specificity of change within any one school. She underlines the importance of the nature and seriousness of problems regarding implementation. In particular it is necessary to understand the fluid, non-linear and reiterative processes in which multiple factors inter-relate.

Helen Drenoyianni explores whether ICT has changed education—and in particular whether the reformative, humanistic and emancipatory role that many educators have envisaged for ICT in education have been realised. In *Reconsidering Change and ICT: Perspectives of a Human and Democratic Education* she reports that many of the international studies would seem to suggest that educational media and tools cannot revolutionise, but only strengthen further and reinforce established educational goals, curriculum contents, teaching and learning methods. In this sense she asserts that ICT merely becomes assimilated into and exacerbates prevailing socio-economic problems. Indeed the failures of the much heralded 'revolution' are blamed on an evolution that is slower than anticipated, leading to demands for further investment in hardware, software and teacher training. Nevertheless many studies also point to negative effects of using ICT, tying it to rigid curricula, imposing additional workload and increasing inequalities through a digital divide.

In contrast the author proposes that there are a number of success stories that suggest that educational computing provides "space to breathe," and thus a chance to liberate the learner and humanise the school. In these reports computers are seen as powerful cultural objects, pleasurable gadgets and intellectual tools. The question the author poses is how to harness ICT to produce this more humanistic agenda, more favourable learning environment, and thus "democratise education?" She suggests that reading inspiring success stories suggests ICTs can provide a means of revitalising schools and act as a catalyst for a more human and democratic education.

Finally, Ola Erstad in his keynote paper explores how policy makers have used the terms an information society or knowledge society to argue for implementing new technologies in education, and for improving learning. In *Where Do We Go From Here? Digital Literacy, Knowledge Building and Curriculum Reform in Norway* he suggests these views have been highly problematic, in part because they do not take into consideration how new technologies are used by young people, or how schools work as social practices. He defines digital literacy as a key competence in curricula for schools. He believes that combining an increased focus on digital literacy in the school curricula with an increased focus on student-centred learning environments challenges our concepts of a school age learner.

The author reports on 10 years of strategic development in Norway leading to the current emphasis on digital literacy, that is “skills, knowledge and attitudes in using digital media to be able to master challenges in the learning society.” In essence, digital competence relates to use of technology to accomplish both personal and collective needs. But the role of the media as a tool is significant as is a social-cultural resource for human development, it is intimately involved with changing notions of the organisation and structure of learning, and the idea of mediated action. So he emphasises the importance of studying how these new technologies represent new cultural tools and create new meaning structures. It is evident today that young people gain most of their digital competence outside the formal institutions of learning. This has direct relevance to the discussions about learning in schools, and it seriously confronts earlier conceptions of literacy and learning. Especially as many of the experiences and impressions that young people gain from their media use are never incorporated into learning activities in schools. He asserts that the challenge is to overcome the barrier of school settings and reach the ambition of digital literacy in schools through the concept of changes to learning environments. The goal is to achieve learning environments where students are themselves the frame of reference for defining the learning process.

He reminds us that research in Norway as elsewhere indicates some problems. For instance teachers and principals are very positive towards computers, especially for particular projects, but at the same time most teachers do not use computers much in their actual teaching, but mostly for planning. So establishing change in pedagogic practices is difficult to accomplish. It is equally difficult to be clear about what change is going on. But he is certain that the centre of the debate lies in the changing role of school in society and the knowledge building processes going on both inside and outside schools.

4.6 Common concerns

While the papers here have been located under headings, further common themes across the papers are noticeable. These include:

- Acknowledging the complexity of the environment which we explore;
- Recognition that that substantial use of ICT in learning is still not commonplace;
- The different context with ICT now ubiquitous within society; and
- The particular perspective of the young who are at ease with and readily use their digital world.

These papers represent but part of the total presentations and other activities, such as discussion panels and workshops at the conference, including themes of lifelong learning, the school and home, portraits of successful teachers, and using wikis and blogs. All this was being discussed within a framework of “imaging the future for ICT and education.” This topic generated debates that in tone were less certain than the previous decades, that maintained an

excitement and vision of the partnership between ICT and education, but which now places the computer not as a solution but part of the process of innovation in education.

As a benchmark for where we are in 2006, it suggests a more mature community that is shedding its unabashed enthusiasm for a more reflective stance, informed by research that ranges from large-scale surveys to small but ‘telling’ case studies. As a frame for moving forwards, it highlights serious and immediate concerns that need local, national and international debates to include:

- The problematic of using old forms of assessment for new styles of learning;
- Clarifying the inter-relationships of teaching, learning, pedagogy and ICT;
- Tackling ethical dilemmas and digital divides;
- Probing the reality of collaboration and networked communities;
- Recognising digital opportunities;
- Understanding the role of learning organisations in a knowledge society; and
- Focusing on lifelong learning.

One word however frequently occurred in papers and debates, but was not explored in its own right—*change*. It was noticeable that although we were discussing changes in schooling, learning, teachers, and the technology, we were not using theories, models and knowledge of innovation and change to help us in our quest for understanding our field.

5 Understanding innovation and change

There can be no doubt that the world of ICTs in education is embedded in innovation and change. And yet there is relatively little reference to models or theories of change as an underpinning conceptual framework to understanding what has been happening. How come we have paid it scant attention? In the following section I will argue for attention to both systematic change for organisations and the experience of change for individuals, and also to the notion of change as a process and alternative perceptions about managing change.

There have been a number of management and sociological studies on the identification of stages in the process of innovation (Clarke, 1994; Lewin, 1952; Morrison, 1998; Rogers, 1995), and for education in particular of planned innovation during times of curriculum innovation or changes in government policy. Following Lewin (1952) these models often take a linear, systematic approach to change which propose the organisation of change through phases of, for instance initiation, implementation, continuation and outcome (Fullan, 1991) or initiation, adoption, adaptation, acceptance, use, and incorporation (Kwon & Zmud, 1987). Later versions include feedback loops, but the sense of essential stages remain. Some take a top-down management approach; others focus on the role of a change agent as a catalyst within the innovation process. The structure of a system or organisation and the specific nature of the innovation lies at the heart of these models. This suggests that an innovation can be contained and harnessed. If the planned innovation does not appear to be fully implemented or embedded, then specific phenomena might be identified as resistance points. Teachers have often been characterised as resisters to educational change; this has also been the case with ICT.

The anthropologist Katz (1961) however, discussed the social itinerary of technical change. Using studies of technology change in medicine and farming, he advocated the notion of studying the process of diffusion by tracing (a) the movement of a given new

practice, (b) over time, (c) through specific channels of communication and (d) within a social structure. Using such method provided the opportunity to understand the social characteristics of innovators, how they adopt the change, and the strong interpersonal influence in the diffusion process within communities of practice. Rogers (1995), also writing in association with technology, while still identifying phases, refers to four elements to the diffusion of innovation—the innovation itself, communication channels, time and the social system. And he further identifies a range of issues which might influence the success of failure of change, which include appropriate methods for communication at appropriate times, the innovativeness of individuals, types of adopters and differing rates of adoption, a social system that includes an understood structure and norms, the role of change agents, the influence of leadership, and the decision making processes. This has resonance also with the complexity of changes brought about through ICT.

Rogers (1995) also reminds us that the nature of the innovation itself often goes through a substantial development process, which is in one sense separate from and may run in parallel with the implementation in an organisation. But also that when introduced into organisations, the innovation may then interact differently within an organisation than during the development stage. We struggle within the ICT world to accommodate the dynamics of changing technologies and changing schools; yet here is a framework to consider their interconnectivity in a parallel and yet connected frame. Zaltman and Duncan (1973) place an emphasis on the complexity of the implementation stage, and specifically the relationship between the organisation and individuals within it, and the critical question of who decides to adopt an innovation. We know that the role of innovators and powerful leaders regarding ICT use is significant; we are less sure how the energy and activities of these individuals can be translated into lasting change.

Havelock (1970) posits two perspectives on the innovation process; one from the point of view of people who are being changed, and the other from the point of view of someone who is trying to change someone else. The former is the client system, the latter the change agent. It is interesting to explore how effective governments have been in their role as change agents in education in general, and ICT policy in particular, where reality does not reflect the rhetoric. Schon (1983) writing on the centre-periphery model, reminds us that too often change is planned from the centre to ‘flow out’ to the periphery, without due attention to change emanating from the ‘bottom up.’ Thus an alternative perspective to the systematic approach of organisations through stages of change is to consider the individual’s approach to change, and concerns with people’s perception, attitudes, values, beliefs and opinions (Morrison, 1998).

Hall and Loucks (1975) suggest people have different concerns during stages of the innovation process, where concern relates to the feelings, preoccupations, thoughts and the specific considerations people give to a task. Interrelated with understanding people’s concerns is the notion of measuring what the individual user actually does when using the innovation, as a prelude to trying to understand their behaviour. There is a growing corpus of studies that illustrate what teachers and pupils actually do with, for instance, collaborative tasks and online fora. Then equally focused on people’s attitudes, intention and behaviours is the work by Adzen and Fishbein (1980), which aims to understand and so predict and individual’s behaviour and actions. Their theory is based on people’s intentions to act which reflect their individuality and societal norms. Intentions are also subject to the influence of external factors, such as opportunity and the cooperation of others, which may influence the ability and scope of action. Both these approaches provide frameworks for more clarity in understanding the complex responses to using ICT in education. In

particular teachers can be seen as coping with possibly too many issues rather than automatically resisting change. They could present equally useful modified frameworks for student behaviours and actions.

Both the strategic structural models and those based on the concerns and activities of individuals provide useful theoretical frameworks to explore the extraordinary complexity of innovation and change. In many ways innovation and change can be classified by two distinct approaches—identify a problem and the structural changes needed to solve the problem, or focus on the people in organisations involved as sentient, dynamic systems. It is clear that in education the human dimension is critical.

Finally Smale (1998) enables us to address a new model for managing change through innovation by shifting from the notion of stages and proposing instead sets of interlocking triangles, using the triangular rather than linear form as a symbol of change. These interlock and represent levels of activity rather than stages of development. He further proposes that this model allows for a spiral of change, where the activities and changed perceptions within different triangles may overlap and influence other activities as a continuous motion through change. Jiamton (2006) considers this particularly important. Her findings reflect others from the literature which suggest that a clear aim in association with an innovation such as the technology, may not be apparent in the early stages of the change process; rather regular iterations through cycles of perspectives of the organisation, the innovation and the people involved, reflect the complexity and dynamisms of change.

Indeed the implementation of organisational change in education is central to our concerns. Kozma (2003) reports from the substantial SITES2 study of 174 cases across the world, selected because they exemplified the use of ICT in education. He states that a number of the positive messages about what can happen using ICT for learning are true—but these depend on a complex set of variables being a necessary pre-condition. In particular, he asserts that coordinated strategies for change and more models of technology intensive learning are needed. He indicates that all forms of societal institutions even schools are altering slowly but radically. He also reminds us that we are already inhabiting a profoundly interconnected, knowledge-based, global market place. A further conundrum is posed when he argues that the complexity of this innovation has been seriously underestimated.

In our field we have three interlocking areas of change interacting together—technology itself, education, and society itself of which both are but a part. I would maintain that using theories and models of innovation and change will help us ground our new empirical work within a perspective that acknowledges the complexity of both the nature of innovation and the change process, and which allows a reflection upon the reality in context. Thus the world of the technology itself, as the innovation, becomes part of a more complex picture rather than the more rarified presence it sometimes held in the past. I do not propose that such theories and models will provide solutions; rather they may enable us to give greater shape to the substance of the issues, dichotomies, and decisions we face. This is only one perspective, but the need to understand and explore the concept of change is I believe a critical undercurrent in the papers presented here.

6 A coda

This paper has been written as an introduction to the papers of this special issue on imaging the future for ICT and education. As such there is no place for a conclusion—but a coda enables me to provide one personal reflection.

Many of the participants reflected on the significance of international face to face meeting and communication. By meeting as a real community, where language diffe-

rences—from the metaphors we use and the vocal emphasis we place within sentences—forced us to probe and explore meanings in depth. Such an international meeting reminded us of how bounded we are, and how easy it is to remain metaphorically within individual ‘boxes’. The explorations through formal sessions, informal meetings and during the social programme reminded us of the commonalities and differences which need observing, protecting and celebrating.

And located at the junction of soaring mountains and an enormous ocean, Alesund in Norway represents the endurance of communities in challenging conditions, combined with a sense of adventure, outreach and exploration—an apt metaphor for deliberations on the future of ICT and education.

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