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Pedagogy, information and communications technology and teachers' professional knowledge

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ABSTRACT

In this article UK governmental policy imperatives to apply new forms of information and communications technology (ICT) to school improvement are explored, with particular reference to the National Curriculum for England and Wales. The analysis juxtaposes the piecemeal, random way in which ICT is used in National Curriculum programmes of study and schemes of work with the government rhetoric that requires coherent planning and integration of ICT within all aspects of teaching learning. The article argues that this contradiction within the policy process could be overcome if a stronger conceptualization of teachers' professional knowledge was embraced. An example of such a conceptualization is presented and this is exemplified by accounts of teachers' development of ICT within their pedagogic practice.

KEY WORDS

pedagogy; teacher professional knowledge; information and communications technology; National Curriculum.

INTRODUCTION

Strong policy aspirations are emerging across the UK to release the potential of information and communications technology (ICT) for teaching and learning. In England and Wales a government document *Teachers Meeting the Challenge of Change* (DfEE, 1998) explicitly links ICT to pedagogy in suggesting that:

> new possibilities are emerging. Throughout this century teachers have had to choose between prioritizing the needs of large groups as following the diverse needs of individuals. Now for the first time they can realistically do both. (12)

In other parts of the UK similar aspirations for ICT exist. In Northern Ireland, for example, a new strategic plan for the education service in the period 2000–2006, 'Learning for Tomorrow's World' places significant emphasis on the role of new technologies. In Scotland, the Consultative Council is introducing new 'National Guidelines ICT 5–14', as part of a national move to encourage teachers to use ICT within the classroom. A £230 million pound programme to train every teacher in the UK in the use of ICT between 2000 and 2003 is being underwritten by the New Opportunities Fund, an organization funded through the national lottery.

In England and Wales particular aspirations have developed for linking ICT more systematically to the implementation of the National Curriculum. The foreword to the revised National Curriculum for 2000–2005 is explicit in stating that this curriculum lies at the heart of government policies to raise standards (DfEE, 1999) (www.nc.uk.net). The rationale for a National Curriculum (DfEE, QCA, 1999) includes the suggestion that teachers should ensure pupils are 'prepared to respond as individuals, parents, workers and citizens to the rapid expansion of communication technologies' (3).

This article will outline some of the most recent research on the impact of information and communications technology on pedagogic practice, and review the way in which ICT is being used in the implementation of the National Curriculum. It will suggest ways in which a clearer conceptualization of teachers' professional knowledge, based on research about learning, might provide a stronger foundation for realizing the ambitions that exist around new technologies.

RESEARCH INTO ICT AND PEDAGOGY

Optimism about the impact that the application of new technologies might have in education has to be matched against an evaluation literature that suggests that the use of ICT by teachers, as well as its effects on their enacted pedagogies, has been consistently disappointing (Sutton, 1991; Ruthven, 1993; Plomp *et al*., 1996; Watson, 1997). The changing forms of ICT that have become available, however, are rapidly outdating such studies. The World Wide Web, which has revolutionized Internet use, for example, was only created in 1994, yet the pace of adoption is eclipsing all technologies before it. Radio existed for 38 years before it gained 50 million listeners, while television took only 13 years to reach that point. For the Internet it was just four

years (Lynch, 1998). By the end of its first fully fledged year of use in 1995, there were 9 million users, and 179 million by June 1999. Projected figures suggest 700 million by 2001 and 2 billion by 2007 – one-third of the population of the planet. In 2000 43 per cent of American homes have Internet access. Europe, while adopting the Internet more slowly, is catching up fast. Access in Scandinavia in 2000 stands at over 40 per cent and in the UK 33 per cent. (50 per cent of teachers have home access (Castells, 2000).) Certainly the exploitation of the Internet within the next few years is likely to lead to access figures in the developed world which are comparable to television. And although there has been much talk of a digital divide between those online and those not, Castells argues that this will not be a traditional geographic 'north–south' divide in the near future. Internet use is rapidly expanding in Asia and South America, for example, and in Africa though to a lesser degree, all showing the same phenomenal growth pattern of North America and Europe.

Such expansion alone goes some way to justifying the educational policy rhetoric in relation to ICT. If the interactivity of the Internet is having a major impact on commerce and public administration, then the potential for educational exploitation must exist. We would go further and argue that such potential not only exists, but needs to be responded to proactively by the educational community, with thoughtfulness, rigour and integrity. Castells (2000) is powerfully demonstrating that the so-called 'digital divide' will be far from being simply a geographical divide. Rather, it will be an 'on connection' divide which will shortly begin to have significant implications for educational policy and practice. The divide will be created by content, not access. In a comprehensive research summary of domain names he shows that Internet content providers are concentrated in metropolitan areas and specific neighbourhoods, with San Francisco, New York and Los Angeles currently dominating and London running in at fourth place. Those who come first, he argues, in such a potentially powerful environment will shape the medium, its form, its content and its market. How ICT is conceptualized, therefore, becomes crucial and on this point some understandings need dispelling.

Research, for example, is pointing to the way in which the use of ICT for teaching and learning needs be understood as an interactive process. When account is taken of the specific settings in which such curriculum activities take place, research indicates a dynamic interaction between people, activities, machines, the available software and other tools within such settings, as well as with the broader educational context. Moreover, numerous recent findings are beginning to indicate that the success of any programme is also dependent upon both context and use within a particular setting (e.g. Collins and Duguid, 2000; Kontogianopoulou-Polydorides, 1996; Windschitt, 1998). Chronaki (2000), emphasizing the context in which the role of information and communications technology in teaching has to be

conceptualized, argues the need for four perspectives on pedagogy when computers are utilized in the classroom. These are, she suggests: the pedagogical orientation of the educational system (at a macro level); the pedagogical structure embedded within the computer system (the software); the pedagogical organization of lessons; and the pedagogical support provided by teachers. This perspective is also reflected in the work of Somekh (1997) based on the experience of the pupil autonomy in learning (PALM) project. Pea (1998) has reviewed the use of computer tools such as the CSILE knowledge forum (Caswell and Lamon, 1999), which can be used to build on and create new syntheses of related ideas, provide scaffolding in areas such as theory building and foster conceptual change. He calls them 'technologies of the mind'. Such tools, he argues, have the potential to offer an 'intellectual partnership', for example in the way they allow young learners to engage in hypothesis formulation and testing at a level and depth previously impossible. Research carried out by Salamon *et al*. (1991) suggests that such a partnership can equip learners with strategies that reorganize and enhance performance away from the technology being used. Davis *et al*. (1997) have also suggested that the quality of learning can be significantly enhanced when ICT is approached and utilized as an intellectual 'multi-tool', adaptable to learners' needs and supportive of their attempts at conceptual abstracting. This research, taken as a whole, underlines that it is not technology of itself but a 'whole cloud of correlated variables – technology, activity, goal, setting, teachers' role, culture – exerting their combined effect' (Salamon , 1991).

Current research also suggests that the success of information and communications technology is dependent upon the way in which a variety of discrete classroom strategies are integrated into the teacher's overall pedagogy (Wood, 1998). A study by Newcastle University (Moseley *et al*., 1999) for the TTA has looked at specific uses in a range of classrooms. It concludes that successful teachers need to take account of a range of factors. These include: 'appropriate starting points for development for particular teachers in accordance with their teaching styles and approaches'; 'a planned match of pedagogy with the identified purpose of ICT activities and learning outcomes'; and 'clear identification of how information and communications technology will be used to meet specific objectives within subjects of the curriculum to improve pupils' attainment'. Passey (1999) has drawn attention to the way in which the boundaries of settings are changing. The advent of a connected learning community, he argues, will have a direct impact on pedagogy in terms of the access it provides to knowledge beyond the classroom, including the influence of ICT use at home, and in the community more generally. His current work suggests that the home can provide a substantial extension to the educational arena if teachers consider the appropriate approaches that can be gained and the potential benefits offered (Passey, 2000). Only recently has the role of ICT for teachers' professional development been explored in any depth. The need

to establish a vision of potential uses to inform professional practice has been argued (Moon, 2000; Leach, 2000). Marx and others (1998) have developed a threefold categorization of applications (multimedia, productivity tools, information and communication systems) as a conceptual framework for professional development. Each of these perspectives indicates features of context and setting as crucial to successful adoption. McCormick and Scrimshaw (2000) have suggested three approaches which indicate a possible spectrum of use of ICT and the implications for teachers' pedagogy: ICT to improve teaching efficiency; ICT to extend teaching and learning; ICT to transform conceptions of subject.

ICT AND THE NATIONAL CURRICULUM

The thrust of this research work is towards creating rich information and communications technology teaching and learning environments which will infuse all aspects of pedagogic practice. In England and Wales the successive moves towards a regulated curriculum (Moon and Mortimore, 1989; Moon, 1990) have been accompanied over the last decade and a half by a corresponding attempt to influence the way in which the curriculum is taught. The revised National Curriculum programmes of study for 2000–2005 have been given a common structure and design across all curriculum subjects. These programmes of study set out the knowledge, skills and understanding to be taught, as well as the breadth of study (i.e. contexts, activities, areas of study and range of experiences) across key stages. Notes are provided in the margins where there are 'Opportunities for pupils to use information and communication technology' as they learn the subject. Each National Curriculum subject document is also accompanied by schemes of work setting out objectives, activities and expected outcomes for each unit, including the use of ICT. While these are not compulsory, most schools will at least refer to the material when developing their own scheme of work. Many schools, given the scrutiny of external inspection, will see it as 'playing safe' to adopt these wholesale.

There is a significant debate to be had about the encroachment of government and government agencies into the areas of teaching methods. Equally curriculum developers and curriculum theorists might look critically at the way in which objectives are devised, subject content suggested and the forms of activity prepared. Many such activities, for example, are mere prompts for teacher talk and class discussion. Our interest here, however, is in the way in which information and communications technology is represented both in the programmes of study and in the proposed activities that would implement specific schemes of work. Such formulations illustrate, at a formal governmental level, the way in which the policy priority to use ICT should be seen in action. At the time of writing, schemes of work have not been approved in two of the core National Curriculum subjects, English and

Key Stage 1 Writing
Pupils could compare print outs from two different drafts of their own writing to check revisions and improvements (20).

Key Stage 2 Reading
Pupils could use moving image (for example TV, film, multimedia) to support their study of literary texts and to study how words, images and sounds are combined to convey meaning and emotion (26).

Key Stage 2 Writing
Pupils could compose on screen and paper (28).

Key Stages 3–4 Writing
Pupils could make choices of font style and size and whether to use bold, italics or bullets in presenting their work (37).

Key Stages 3–4 Writing
Pupils could use a variety of ways to present their work including using pictures and moving images as well as print (38).

Figure 1 ICT opportunities for English (DfEE, 1997a)

mathematics. We have therefore taken our first examples from the English and maths programmes of study within the revised National Curriculum documents. In the English document, across all three attainment targets (speaking and listening, reading, writing) for Key Stages 1–4 a total of five 'ICT opportunities' (sic) are given, as shown in Figure 1. In the maths document there are nine, shown in Figure 2.

Some five years ago the DfEE (1997) set out the kinds of knowledge and understanding that are particularly well supported in English and mathematics teaching by information and communications technology (see Figure 2). These and others have been illustrated in detail through a variety of publications (e.g. Tweddle, 1995; Shreeve, 1997; Millum and Warren, 2000; Richardson and Johnstone Wilder, 1999; Leach and Scrimshaw, 1999) and some are summarized in Figures 3 and 4, by way of example.

Given such detailed work completed by subject specialists, the English and maths National Curriculum 'ICT opportunities' would seem to be at best random, at worst banal and inconsequential. This lack of rigour becomes more serious, given the TTA statutory requirements within England and Wales for newly qualified teachers to have reached a range of Standards in relation to the use of ICT in planning, teaching and assessment. This is in addition to the expectation across the UK as a whole that all teachers will be secure in these Standards, including planning, by the year 2003.

If we turn to the more detailed schemes of work linked to the National Curriculum documents, a similar picture emerges. One example is the

Key Stage 1 Writing
If – ICT
Pupils could use ICT to communicate results using appropriate mathematical symbols.

Key Stage 2
4d – ICT
Pupils could construct and use a formula to transform one list of data to another.

Key Stage 3
5f – ICT
Pupils could use a spreadsheet to construct formulae to model situations.
6g – ICT
Pupils could use a spreadsheet to generate points and plot graphs.

Key Stages 4 (foundation)
5f – ICT
Pupils could use a spreadsheet to construct formulae to model situations.
6d – ICT
Pupils could use a spreadsheet to calculate points and draw graphs to explore the effects of varying m and c in the graph of y=mx+c.

Key Stages 4 (Higher)
5g – ICT
Pupils could use a spreadsheet or graphic calculator to construct and use formulae.
6b–6f – ICT
Pupils could generate functions from plots of data, for example, from a science experiment, using simple curve fitting techniques on graphic calculators, or with graphics software.
6g – ICT
Pupils could use software to explore transformations of graphs.

Figure 2 ICT Opportunities for Mathematics (DfEE, 1999)

ICT can help pupils in English to:

- talk, read and write for a range of purposes
- retrieve and process information from a range of sources
- organize and present information for a variety of audiences
- broaden the range of audiences for their work
- identify characteristics and features of texts
- develop knowledge and understanding of language.

Figure 3 English and IT: a pupil entitlement (DfEE, 1997b)

Learning from feedback	The computer often provides fast and reliable feedback which is non-judgemental and impartial. This can encourage students to make their own conjectures and to test out and modify their ideas.
Observing patterns	The speed of computers and calculators enables students to produce many examples when exploring mathematical problems. This supports their observation of patterns and the making and justifying of generalisations.
Seeing connections	The computer enables formulae, tables of numbers and graphs to be linked readily. Changing one representation and seeing changes in the others helps students to understand the connections between them.
Working with dynamic images	Students can use computers to manipulate diagrams dynamically. This encourages them to visualise the geometry as they generate their own mental images.
Exploring data	Computers enable students to work with real data which can be presented in a variety of ways. This supports interpretation and analysis.
'Teaching' the computer	When students design an algorithm (a set of instructions) to make a computer achieve a particular result, they are compelled to express their commands unambiguously and in the correct order; they make their thinking explicit as they refine their ideas.

Figure 4 ICT in Mathematics: opportunities for exploiting the power of IT (NCET, 1995)

approach adopted in the schemes of work for the history, French Revolution unit. Figure 5 shows the way in which ICT is characterized across the nine sections of the unit of study.

A comparable unit of study in the schemes of work for geography, 'The restless earth – earthquakes and volcanoes' includes:

> What happened in the 1995 Kobe earthquake in Japan?
>
> ICT: this activity provides pupils with the opportunity to use a painting and drawing package.

(1) ICT: pupils could use a drawing or DTP package to combine images from a variety of sources, e.g. CD-ROM, website, digital images, to produce a before/after poster or to present different attitudes to the French Revolution, e.g. which might have appeared in a French revolutionary news-sheet or an English newspaper.
(2) No mention of ICT.
(3) No mention of ICT.
(4) No mention of ICT.
(5) ICT: use a teleprinter simulation application or saved e-mail messages to relay timed messages about the events of the Flight to Varennes into the classroom. Pupils in groups could work out the narrative from the messages and other supplementary information, e.g. *maps and primary sources*. They could use a desk top publishing template to produce a news-sheet telling the story of the flight. They could include editorial comment on the perceived 'loyalty' of the king and queen to the people. Alternatively they could use a template in a desk top publishing package to produce a front-page edition of a news-sheet to demand the death penalty for Louis. They could combine text with scanned images of the cartoons or images from a website or CD-ROM.
(6) No mention of ICT.
(7) ICT: sources about L'Ouverture are available on CD-Rom and website. Pupils can discuss how they will structure their investigation using these resources. They could copy and paste carefully selected text into a writing frame they have created.
(8) No mention of ICT.
(9) A word processor could be used to help pupils organize and edit their writing.

Figure 5 French Revolution Unit (DfEE, 1999)

It is clear from these examples, replicated in the majority of subject documents, that ICT has been added when an idea has come to mind. Far from providing a model of planning for teachers, the ICT is inserted quite at random, rather than being systematically integrated into and across the revised curriculum and its accompanying schemes of work. It is also clear that a number of the examples show computers being used merely for word processing or presentational purposes, rather than for any of the three forms of pedagogic use described by McCormick and Scrimshaw (i.e. to improve teaching efficiency; to extend teaching and learning; to transform conceptions of subject). And an e-mail simulation of the Flight to Varennes by Louis XVI does little to develop an understanding of how communication systems worked in late eighteenth-century France and the significance they had to the way events unfolded.

NEW MODELS OF TEACHER PROFESSIONAL KNOWLEDGE

The relative poverty of the conceptualization of information and communications technology as exemplified in these National Curriculum programmes of study and schemes of work stems in part from underdeveloped models of how teacher knowledge is both conceived and represented. Over the last few years staff from the Centre for Research and Development in Teacher Education at the Open University have been exploring new models in a range of seminars and research activities with teachers. The models that have evolved provide a framework for practice firmly based on research into the learning process. A central rationale is that explicit awareness, understanding and ownership of such frameworks enable teachers to be sensitive to a range of dimensions when incorporating ICT into their pedagogic practice. In addition, recent research on learning both in schools (Newman *et al*., 1989) and other settings (Lave and Wenger, 1991; Rogoff, 1994; Collins and Duguid, 2000) suggests that learning is far more social, contextual and distributed than earlier models have allowed for. Since teachers not only work with learners but are themselves also learners, this new thinking provides new ways of helping teachers rethink their pedagogy (Marx *et al*., 1998). Our major premise, therefore, is that learning is a situated, social process, dependent on interaction and communication (Bruner, 1996); such learning is ongoing and takes place in a wide variety of communities and across a range of settings. A primary interest, therefore, is with the conception, construction and practice of learning communities – communities that develop motivated, confident, autonomous young people. Significantly, in relation to the use of information and communications technology, cognition from a situated perspective is seen as distributed, 'stretched over' the individual, other persons, activities and tools in the setting (Lave, 1988; Putnam and Borko, 2000). Such conceptualization appears to go with the grain of seeking to understand the multiple influences that impact on the pedagogic practice of teachers.

One of the strengths of this situated view of learning is its ability to encompass a variety of settings. It is sensitive to the wider school and community impact on learning, as well as taking account of the role outsiders can play in communities, particularly where ICT is a key element. Such a perspective removes the idea of a mere physical surround to a teaching and learning situation. The notion of 'learning communities' is increasingly important as the communications aspect of information and communications technology develops, in particular as the national and international developments outlined in our introduction begin to have a direct impact on the classroom. In exploring pedagogic practice we have used two organizing categories: the *pedagogic arena* (i.e. the broad context in which learning activity takes place) and the *pedagogic setting* (i.e. the actual practice of teaching and learning within such an arena). The concept of arena is based on Lave's (1988) use of

the term; she defines it as a physically, economically, politically and socially organized place in time. A setting is the repeatedly experienced, personally ordered and edited version of the arena. Pedagogic arenas and pedagogic settings (Leach and Moon, 1999) are contexts and practices intentionally orientated towards the development of teaching and learning. As such, we have argued, they can be analysed across a number of interrelated dimensions which provide a strong focus on learning:

- educational goals;
- the knowledge that is the subject of the learning;
- learning purposes;
- learning and assessment activities;
- teacher-learner roles and relationships;
- discourse.

A pedagogic arena and a pedagogic setting can be explored at a variety of sites and levels. Policy-makers, teachers, software designers, educational website creators and parents, for example, all create pedagogic arenas, their specified 'curriculum' being manifest through these pedagogic dimensions, whether explicitly or implicitly. Arenas are brought to life in particular pedagogic settings – the practices that teachers, together with a particular group of learners, create, enact and experience. Thus the notion of a pedagogic setting can, and should, encompass individuals and the group or community as a whole as the unit of analysis. Settings just as much reflect teachers' own perceptions of their core task of teaching (and learners' experiences of and interactions with this endeavour) as they are the outcomes of the mediating influences of institutional goals, activities, structures and policies at local and national level. How teachers introduce and develop information and communications technology into the, often taken for granted, settings and the way in which such changes impact on the pedagogic dimensions (e.g. learning purposes and assessment outcomes) is our core concern. While a proposed ICT intervention might focus on only one, or a selection of the above dimensions, preliminary research suggests that this will impact on other dimensions. It will affect the setting as a whole, individual learners' experience of that setting, as well as (crucially) the nature and quality of the learning taking place.

We have noted with interest the elements of 'professional characteristics' and 'classroom climate' emphasized in the Hay Macber Report (2000) on teacher effectiveness. It is a concern to us in relation to such a major policy document that while the findings suggest that the most effective teachers 'like teaching their subject' and have a 'passion for learning', there is no underpinning model of learning. In addition, there are few references to the curriculum and in particular to teacher professional knowledge. One of the few references that does exist is to teachers' knowledge of new technologies, although the reference is somewhat rhetorical:

> In addition to the careful planning of mainstream lessons and programmes of work, effective teachers think ahead. This enriches the curriculum and makes learning relevant, and coherent, and enables planning of special events, or being able to tie in programmes of work with local, national or world events.
>
> Technology is reshaping future teaching and learning methods, and effective teachers think ahead to take advantages of opportunities this and other developments provide. They are ahead of the game, so they can make lessons and programmes of work relevant to the way life will be for pupils after they leave school. (16)

Given a concern to encourage the process of teacher development, as well as to change classroom practice and improve the quality of teaching and learning, we believe it is necessary to consider the interaction of the concepts of arenas and settings with what is now understood about teacher knowledge. This includes subject and pedagogic knowledge. Figure 6, based on substantial developmental work with teachers (Banks, Leach and Moon, 1999), represents our model of this interaction encompassing the pedagogic dimensions.

This model emphasizes the dynamic, process-driven nature of 'subject' knowledge that encompasses essential questions, issues and phenomena

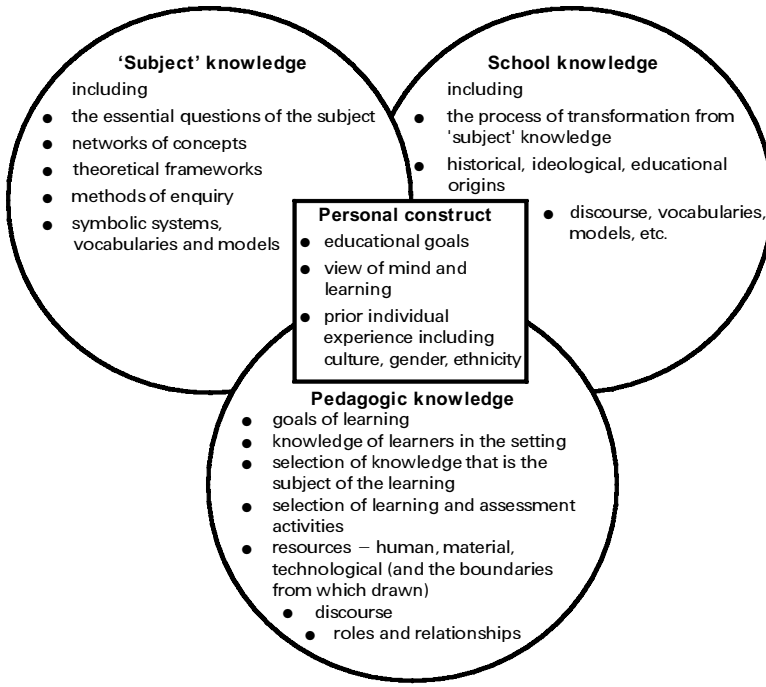

Figure 6 Teacher knowledge used in creating a pedagogic setting

drawn from the natural world, methods of enquiry, networks of concepts, theoretical frameworks, techniques for acquiring and verifying frameworks, symbolic systems, vocabularies and mental models (Gardner and Boix-Mansella, 1994). 'School' knowledge is seen as an analytical category in its own right. This is specifically curricular related knowledge – the transposition, at a number of levels within any teaching and learning system, of the 'subject' knowledge referred to above. 'Pedagogic' knowledge is rooted in an understanding of the crucial relationship between subject knowledge, school knowledge and knowledge of learners. Central to this process are the personal constructs of the teacher, a complex of identity (encompassing, for example, past experiences of learning, gender, ethnicity and subject), a personal view of what constitutes good teaching (educational goals), and a belief in the purposes of the 'subject'. This category would encompass, but go well beyond, elements such as 'passion for learning' and 'likes teaching the subject', identified by Hay McBer (2000) as characteristics of effective teachers.

In the process of researching these models we have been exploring numerous examples of teachers using information and communications technology. Many of them are utilizing ICT in a way which would certainly confirm the Hay McBer characterization of 'outstanding teaching'. But such teachers display additional and, we would suggest, more significant teacher knowledge. Such practice includes, for example, Beverly Caswell's use of the CSILE knowledge forum software (OISE, 2000) to scaffold the work of the scientific community of 9-year-old pupils she has encouraged to develop in her classroom setting. In this particular setting her young students were encouraged to work in small experimental groups to study the Giant Madagascan hissing roach. The CSICE software enabled them to engage in depth with self-chosen research questions on the evolution, perception, learning, anatomy or communication of these creatures (Caswell and Lamon, 1999) Caswell and her co-researcher Mary Hanan's subject knowledge of the essential questions, purposes and disciplinary frameworks of the subject domain.

The Merseyside and Kent teachers who have used the Internet to both encourage and enable exciting digital art collaborations between post-16 art students showed similar in-depth subject-related knowledge (Open University, 1999a). However, their use of the Internet also enabled students to transform physical objects into digital images, providing a medium in which students could explore visual phenomena, experiment with visual language and extend the range of tools currently used for school art, including image manipulation and layering. Here we also note the importance of the teachers' 'school' knowledge, as they ensured that key aspects of subject knowledge were transformed into relevant curricular related outcomes.

The National Curriculum religious education scheme of work (Unit 9C: Why do we suffer?) suggests for its single ICT component that teachers might

> Ask the pupils to use websites or CD-ROMs to research an example of suffering and to report back to the whole class

we have been more impressed by the focused knowledge planning and practice of R. E. teacher Diane Wilson at Coleridge School, Cambridge (LSP RE CD-ROM). Diane integrated a range of resources to support pupils' learning across six lessons (including the internet, CD-ROMs, a scanner, and word-processing software). She chose to use a major news story, the Kosovan refugee crisis, as a starting point for her 14–15-year-old pupils, including several with learning difficulties, to reflect on the meaning of suffering and their responses to it. Students looked at and evaluated electronic newspapers from around the world, explored the websites of a variety of charities and organizations, such as Amnesty International, and used searchable databases containing religious texts. Individual students chose and researched one article of the Universal Declaration of Human Rights, while other pupils took the opportunity to compare data between countries, researched through links to the CIA Countries Factbook, and comparing, for example, infant mortality rates. In relation to Diane's work we might have selected the development of her 'pedagogical' knowledge for particular comment; however, the interrelation of the four elements shown in Figure 6 makes this a difficult choice to make.

Certainly in these, and many more instances of practice, we have observed classroom teachers integrating and developing these four aspects of professional knowledge, drawing on the guiding skills and processes of their subject specialism in quite specific and creative ways. In each of these instances we also see teachers' pedagogical knowledge, including the use of ICT, being integrated with subject and school knowledge to improve and extend pupil learning and, in the case of art, to transform the nature and outcomes of learning in the subject itself.

It is beyond the scope of this article to illustrate in any detail the way in which pedagogic settings are transformed by the use of ICT. However, since we have stressed the situated nature of learning and the centrality of context and social process in curriculum change, we will conclude this article with one brief illustration. We sketch a new development in teacher knowledge arising out of the introduction of new technologies in a history classroom, and summarize how this particular element of change was integrated into a scheme of work, and in turn affected a particular classroom setting.

The history Year 9 scheme of work, 'How and why did the Holocaust happen?' (see the Standards site www.standards.dfee.gov.uk), notes the following in its sole reference to information and communications technology:

- A number of websites also offer useful material, but care must be taken in accessing websites as many contain racist material and Holocaust denial material.
- Pupils can be presented with structured worksheets on file which present Internet links to relevant sites. Pupils might be encouraged to choose an appropriate format to present their group's work to the rest of the class.

Alan November (November, 1998) was a high school teacher in the United States. He tells the following story of how he came to realize the importance of developing new school and pedagogic knowledge in his own history teaching:

> *Fourteen year old*: 'I'm working on a history paper about how the Holocaust never happened.'
> (*Long pause*) 'Zack, where did you hear that the Holocaust didn't happen?'
> 'The Internet. It's on a Web page at Northwestern University.'

To survive in the future economy, November argues, as a result of this experience, children must learn how to research, publish and communicate working with the Internet and other information tools. It is not *how* to use Windows or Netscape that is the most important thing for children to learn and for schools to teach. Instead, knowledge of the Internet needs to involve asking questions such as: What is the website trying to do? Why was it created? (*purpose*); Who is the author and what qualifies them to be an expert in this field? *Author(s)* is the URL a personal home page or an accredited organization? What does this website look like in the context of my knowledge of the web as a whole? What other sites does its link command take us to – what does this tell us about what kind of information the web authors value? (*Meta web information*). Gradually, November began to develop and publish strategies for this 'information literacy' for fellow teachers on the web (See Teaching Zack to Think, www.anovember.com/articles/zack.html/).

History teacher, Jim Fanning, based in the UK, has explored November's work with interest on the Internet. He regularly uses multimedia applications, Internet access and CD-ROMs as an integral part of his history teaching and he believes that the Internet can make an exciting and important contribution to school history teaching. His own work has moved beyond the kind of passive response to concern about the Internet expressed in the National Curriculum history schemes of work above. 'Initially the criteria pupils used for the reliability of information from the Internet was the manner in which it was presented,' Jim comments about his pupils. 'But after I had explained the way in which anyone with an interest could set up a website, they began to be more critical of the materials in front of them.' Jim thus began to develop his knowledge of 'information literacy' (i.e. providing students with the critical tools with which to evaluate the Internet and its resources) and, like November, to realize its importance in the teaching of history.

Jim's work shows subject, school and pedagogic knowledge intersecting, while a closer look at his pedagogic setting indicates the importance of setting and context in the enacting and development of this professional knowledge. For example, he has used six lessons to teach the 'Great War' in his East Sussex classroom. Pupils used CD-ROMs and the Internet and had access to

a disk resource on using the Internet during these lessons, Jim ensured he knew which pupils already had experience of using the Internet. A brainstorming session was used to create a list of research topics with pupils, which included: life on the Home Front; U-boat warfare; the technology of war; Wilfred Owen and the war poets; the battlefields 'now and then'; the role of 'women in the war'. Pupils chose a subject and then worked in groups with a shared interest. One group, for example, working on the topic of 'The battlefields now and then' decided to design a presentation of a field visit they had made to Belgium, as well as to concentrate on the interpretation of sources. They used a range of digital images that they had taken on the original visit and during one further trip to Ypres. Preparing an outline of their presentation on paper, pupils then sought advice on turning this into a web page using Publisher, to be incorporated into the school website.

By the final lesson of the unit, all pupils had managed to put together a presentation. During the research one pupil discovered from her relatives that:

> My great-grandfather was killed in the war. He died on the first day of the Battle of the Somme, 1 July 1916, along with thousands of others. His only memorial is on a wall in a field in France.

Another pupil produced a word-processed description of her visit to the *Memorial to the Missing* at Thiepval, on the Somme. This was used by fellow pupils in their work and also published by the local newspaper, the *Sussex Express*, and by *New Chequers*, the quarterly magazine of the Lochnagar Society. Two other members of the class carried on with their research and produced a website that was entered for the 1998 National Educational Multimedia Award. Their 'end product' was a blend of traditional and 'hi-tech' research: 'they combined information from their field study visit, textual details from a history book, along with material from original film footage taken in 1916, and combined it to create an ICT presentation. The web page they created may look simple', argues Jim, 'but the level of research that went into it, the range of skills required, and the variety of information they combined, would not have been possible had the exercise not involved the use of elements of information and communications technology.'

Jim's own evaluation of this work suggests development of his own:

- Pedagogic knowledge, leading to more effective learning and enhanced student engagement with historical enquiry.
  'The use of the Internet engaged the enthusiasm and interest of pupils in a way that using classroom-based textbook research could not.'
- Subject knowledge, leading to an extension of learning for pupils including increased complexity in asking historical questions.
  'A key feature of the Great War project was the way in which pupils discussed the information they had collected from either the Internet or from CD-ROMs. Pupils were charting territory that may be every bit as

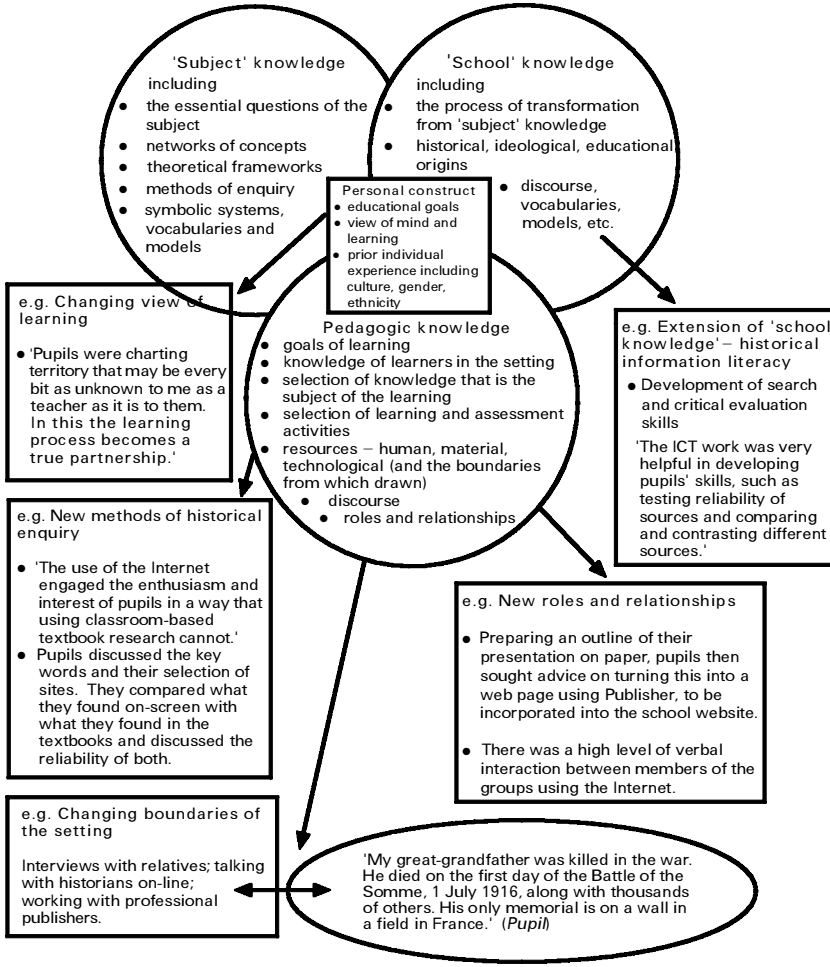

Figure 7 New elements of teacher knowledge in a Year 10 GCSE class in a rural school in Wales – the Great War project

unknown to me as teacher', Jim recounts, 'as it is to them. In this the learning process becomes a true partnership.'

- School knowledge in terms of the development of new 'historical information literacy skills'.

ICT has enabled Jim to begin to develop new skills with his pupils, such as testing the reliability of sources and comparing and contrasting different sources on the web. The use of ICT significantly changed other dimensions of the setting as shown in Figure 7, in particular: learning and assessment activities, discourse and teacher learner roles and relationships.

CONCLUSION

Examples such as this illustrate limitations in the way pedagogy and ICT have been exemplified in the National Curriculum programmes of study and schemes of work. Some earlier, more creative thinking has been bypassed as different groups, working to different timetables and agendas, have attempted to formulate guidance. The specified curriculum at the national level in England and Wales is significant. It provides the basis for the testing and inspection regimes that tightly constrain the curriculum enacted in schools and classrooms. If ICT is poorly presented here, what are the implications for the rhetoric of policy that exhorts teachers and schools to address ICT in a holistic and rigorous way?

There is some informal indication that, at government level, there has been bureaucratic infighting about the prominence to be given to the development of ICT. There appear to have been some, for example, with responsibilities for the literacy and numeracy strategies who perceived ICT training for teachers as a potential diversion from established government priorities. If so this is a further illustration of the way ICT is not being integrated into policy development around the National Curriculum. Success in individual pedagogic settings occurs in spite of policy development in what we have termed the pedagogic arena. If government commitment to new technologies is to have any influence on systemic improvements the quality of national advice and documentation needs to be significantly improved. At the heart of this process should be a much stronger conceptualization of teachers' professional knowledge.

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