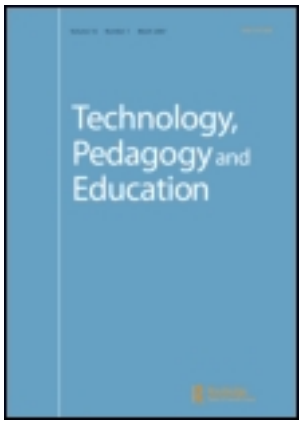

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Factors affecting teachers' use of information and communications technology: a review of the literature

Shazia Mumtaz [a]

[a] University of Warwick , Coventry, USA

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Factors Affecting Teachers' Use of Information and Communications Technology: a review of the literature

SHAZIA MUMTAZ
University of Warwick, Coventry, United Kingdom

ABSTRACT This article reports on the literature associated with practising teachers' uptake of information and communications technology (ICT). Studies reveal a number of factors which influence teachers' decisions to use ICT in the classroom: access to resources, quality of software and hardware, ease of use, incentives to change, support and collegiality in their school, school and national polices, commitment to professional learning and background in formal computer training. The review highlights the role of pedagogy and suggests that teachers' beliefs about teaching and learning with ICT are central to integration. It is suggested that successful implementation of ICT needs to address three interlocking frameworks for change: the teacher, the school and policy makers.

Introduction

Research findings over the past 20 years provide some evidence as to the positive effects of the use of information and communications technology (ICT) on pupils' learning. In spite of such projects, the effects of numerous training programmes and an investment by schools in ICT resources, there has been a disappointingly slow uptake in schools (Cox et al, 1999; Passey & Samways, 1997). This article examines the factors involved in the take up of ICT in schools. It is based on an extensive review of the literature associated with teachers' responses to ICT. It is divided into sections which examine:

- factors that discourage teachers from using technology;
- schools as organisations;
- factors that encourage teachers to use technology;
- the role of the teacher in relation to ICT and its effect on pedagogy;
- teachers learning to integrate technology into their teaching.

The review is followed by a discussion in which the role of pedagogy in the use of ICT is emphasised.

Factors that Prevent Teachers from Using Technology

A number of early studies investigated why teachers do not use computers in their teaching (Rosen & Weil, 1995; Winnans & Brown, 1992; Dupagne & Krendl, 1992; Hadley & Sheingold, 1993). Not surprisingly they found a list of inhibitors:

- lack of teaching experience with ICT;
- lack of on-site support for teachers using technology;
- lack of help supervising children when using computers;
- lack of ICT specialist teachers to teach students computer skills;
- lack of computer availability;
- lack of time required to successfully integrate technology into the curriculum;
- lack of financial support.

Evans-Andris (1995) summarised three styles of computing use among teachers: avoidance, integration and technical specialisation. These styles play a significant role in student access to computer technology. Her study evolved over an 8-year period in the elementary schools of a large metropolitan area. The dominant style of computing among teachers was that of avoidance. Here teachers typically distanced themselves from computers and otherwise reduced the amount of time they spent attending to computer-related activities. Their pupils had limited and repetitive use of software intended for drill and practice or word processing. Generally these teachers sustained a low level of interaction with students while they worked with computers. In contrast, teachers engaged in 'integration' generally embraced computers. They integrated the technology into their teaching methods and curriculum, their working day, and the learning experiences of students. They selected drill and practice software based on curricular goals and the needs of their students. In addition they introduced a broad range of computer applications and developed creative and engaging projects that integrated computer activities with more normal instruction.

As in integration, teachers engaged in 'technical specialisation' embraced computers and viewed the technology as a challenge. These teachers promoted computers in their schools and their activities relating to computing typically demonstrated strong teaching methods such as consistent use, preparation, and delivery of planned lessons involving the computer. During lessons they generally integrated the computers rather than using them to supplement the traditional curriculum. They also focused their efforts on teaching students about the technical aspects of the computer.

Robertson et al (1996) argued that teachers' resistance to computer use was divided into several broad-based themes:

- resistance to organisational change;
- resistance to outside intervention;

- time management problems;
- lack of support from the administration;
- teachers' perceptions;
- personal and psychological factors.

They carried out a study that looked at the information technology (IT) skills of staff and Year 8 students in a secondary school prior to receiving personal palmtop computers after a short acquaintance with them. Access to the palmtop increased the staff's use of generic applications in their work, particularly for administration (e.g. class registers and assessment scores). A minority of staff remained unconvinced about the potential of the computer and many were dissatisfied with the amount and quality of professional development in the use of the palmtop and in ICT in general. Students learned about the main content-free applications relatively quickly and used them frequently. (Content-free software aims to represent flexible tools which can be shaped by teachers or learners to suit their needs; such as word processors, desktop publishers and databases.) This study, like many others, concluded that there is a need for adequate and careful training so that teachers become aware of the range of uses and possible benefits of ICT.

Schools as Organisations

In a study of projects to promote educational changes in America, Canada and the United Kingdom (UK), Fullan (1991) found that one of the most fundamental problems in education reform is that people do not have a clear and coherent sense of the reasons for educational change, what it is and how to proceed. Thus there is much faddism, superficiality, confusion, and failure of change programmes, unwarranted and misdirected resistance and misunderstood reform. He maintains that teachers who resist change are not rejecting the need for change but are often expected to lead developments when they are given insufficient long-term opportunities to make sense of the new technologies for themselves. However, Davis (2000) argues that schools are changing to respond to their communities' need for technology training and their own need for increased resources. This includes a primary school where parents have become support staff and provide courses to other adults in a rural region. Leaders need to become aware of this pervasive nature of ICT so that they ensure that their organisation continues to fulfil its proper function, albeit by increasing its response to a widening remit.

Cuban (1993) provides an explanation as to why new technologies have not changed schools as much as other organisations:

> First, cultural beliefs about what teaching is, how learning occurs, what knowledge is proper in schools, and the student-teacher (not student-machine) relationship dominate popular views of proper schooling.

> Second the age-graded school, an organisational invention of the late nineteenth century, has profoundly shaped what teachers do and do not do in classrooms, including the persistent adaptation of innovations to fit the contours of these age-graded settings. (p. 186)

Cuban went on to describe three possible scenarios for the classroom of 2003, 10 years after his article appeared in press, which he called the technophile's, the preservationist's and the cautious optimist's. The technophile's scenario of electronic schools of the future is one where an abundance of better machines and software enables students to 'learn more and with less difficulty' (p. 192). In this scenario 'students will come to rely on the machines and one another to teach them and that teachers will become coaches to help students with what needs to be learnt' (p. 193). The second scenario is the preservationist's, in which the fundamental structures of schools are maintained but schooling is improved. Technology is perceived to be important but only as a tool that teachers use to help students be more productive. In this scenario technology is used to support what schools have always done. Cuban calls the third scenario the cautious optimist's and is one in which there is a slow but steady movement 'towards fundamental changes in teaching and schooling' (p. 195).

Dawes (1999) discusses how the notion of 'teacher resistance' to change is prevalent in the literature concerned with schools as organisations, and particularly in work dealing with the introduction of new technology. She argues that teacher resistance is a convenient phrase arising from lack of understanding of the work that goes on in schools. An alternative way to consider what happens during implementation of change is that, armed with their professional knowledge, teachers make informed and rational choices about programmes and materials they are asked or required to use. They take decisions that are intended to confirm their beliefs about the educational effectiveness of innovations, and in fact practicable innovation and organised change happen constantly in schools. Rather than 'resistant', teachers might more constructively be considered as selectively welcoming of suitable change. 'Teacher resistance' is a stereotyping of the profession.

Dawes's study examined some images of teachers as computer users in cartoons and comic strips, and showed how these images reflected unfortunate and unwarranted stereotypes of teachers and their relationship to ICT. She argues that such cartoons are responsible for keeping 'alive and familiar' notions of lack of expertise in the teaching profession, even in publications designed to promote ICT use. Three themes, teachers as fearful, teachers as inept, and teachers as less capable than students, are regularly transmitted in the authoritative context of the national press. There is no reason to suppose that once real barriers are overcome teachers will be unable to use computers effectively.

Factors that Encourage Teachers to Use Technology

Cox et al (1999) carried out a study examining the factors relating to the uptake of ICT in teaching. A questionnaire was designed to collect evidence from teachers and other educators about their ICT experiences, expertise and use in teaching, their attitudes to the value of ICT for teaching and learning, the training they had received and, when relevant, their reasons for being a member of an association like MirandaNet, The National Association of Coordinators and IT Teachers and Teachernet UK. The sample consisted of 44 male and 28 female computer-using teachers with a mean age of 42 years. The results showed that the teachers who are already regular users of ICT have confidence in using ICT, perceive it to be useful for their personal work and for their teaching and plan to extend their use further in the future. The factors that were found to be the most important to these teachers in their teaching were: making the lessons more interesting, easier, more fun for them and their pupils, more diverse, more motivating for the pupils and more enjoyable. Additional more personal factors were: improving presentation of materials, allowing greater access to computers for personal use, giving more power to the teacher in the school, giving the teacher more prestige, making the teachers' administration more efficient and providing professional support through the Internet.

Veen (1993) carried out a study 8 years earlier to describe the day-to-day practice of four teachers from a Dutch secondary school who were implementing ICT in their classrooms. The teachers were provided with a computer at home, and a computer and a liquid crystal display in their classrooms. School factors played an important role in how the teachers made use of their computers including the essential technical support of 20 hours per week and the positive attitude of the principal. However, teacher factors outweighed the school factors in explaining the teachers' use of computers. These teacher-level factors were grouped into two subcategories: beliefs and skills. The most important of these were teachers' beliefs regarding what should be in the curricula (content) and the way in which their subjects should be taught (pedagogy). The skills that most influenced their uses of computers were those related to the teachers' competence in managing classroom activities; to their pedagogical skills; and, less importantly, to their computer-handling technical skills. The most important finding from Veen's work is that if the software matched the teacher's pedagogy they used it.

Several studies (e.g. Becker, 1994; Hadley & Sheingold, 1993; Sheingold & Hadley, 1990) used survey data to identify factors likely to be in evidence in teachers who to some extent have integrated computers into their teaching practices. Sheingold & Hadley (1990) conducted a nationwide survey of fourth to twelfth grade teachers in the USA. The three major factors involved in these 'accomplished' teachers' success were:

- teacher motivation and commitment to their students' learning and to their own development as teachers;
- the support they experienced in their schools;
- access to sufficient quantities of technology.

In addition, these teachers worked in schools where hardware and access to resources were twice the average, were comfortable with technology and used computers for many purposes. They perceived that their teaching practices became more student centred with the integration of technology in their curriculum and they held higher expectations of their students. Sheingold & Hadley's (1990) study also identified that the source of motivation for teachers to use technology included gains in learning and using computers for their own development as teachers. They foresaw wider success among teachers if 'ample technology, support, and time for teachers to learn the technology are provided, and if an academic and cultural structure exists to encourage teachers to take an experimental approach to their work' (p. 30). These are all areas that created barriers to using technology identified in the earlier section.

In Hadley & Sheingold's (1993) report, segmentation analysis was used to assess if there were common responses that identified subgroups in the sample. This analysis indicated that there were five main segments or types of teachers and circumstances in this sample, including 'enthusiastic beginners', 'supported integrated', 'high school naturals', 'unsupported achievers' and 'struggling aspirers'. These subgroups diverged on the following factors: (a) experience and comfort with technology; (b) grade level taught; (c) applications and practices they use, and (d) extent of support/colleagues at school. This analysis indicates that not all 'accomplished' technology-using teachers possess similar qualities, but that a diverse and complex combination of factors have had an impact on their path to success.

Becker & Riel (2000) is a recent study on constructivist classrooms that examined the relationships between professional engagement and teaching practice, including instruction involving computer use. Professional engagement was measured by the frequency that a teacher had informal substantive communications with other teachers at their school, the frequency and breadth of professional interactions with teachers at other schools and the breadth of involvement in specific peer leadership activities, mentoring, workshop and conference presentations. The study found that teachers who regularly participate in professional interactions and activities beyond their classroom teach in different ways than teachers who have minimal contact with their peers or profession. The more extensively involved teachers were in professional activities, the more likely they were to have teaching philosophies compatible with constructivist learning theory, teach in ways consistent with a constructivist philosophy and use computers more and in exemplary ways. Their use of computers with students was not limited to gaining computer competence, but extended to involvement in

cognitively challenging tasks where computers are tools to promote communicating, thinking, producing, and presenting ideas. Data on software use and objectives for computer use suggest that these teachers recognise the features of technology that grant students access to a broader community and knowledge base beyond the walls of the classroom. They are able to incorporate the use of computers into student activity more effectively than teachers who fail to participate in their professional community. Such teachers are more likely to focus on traditional methods of delivery of information, on direct instruction. They do not place a high value on collaborative knowledge building in the classroom or for themselves in the educational community. The role of the student is to listen, learn and repeat. Becker & Riel concluded that those teachers extensively involved in professional activities are in a position, with sufficient authority and time, to help other teachers move towards being more accomplished users of computer technology.

Carney (1998) examined a teacher development programme, STDC (the Shortline Teacher Development Centre), aimed at integrating technology into the constructivist classroom. Carney further explored whether several factors common to exemplary computer-using teachers are addressed in the setting. Analysis is focused on the four elements deemed crucial for effective teacher learning:

- Challenges to frames of reference. To generate new responses, professionals must be placed in situations of uncertainty. Three forces seem to be creating these conditions of uncertainty: technology, new teaching contexts and converging reforms. The need to integrate technology is the most powerful of the three in challenging familiar practice and knowledge.
- Situated learning. The notion of situated cognition (Brown et al, 1989) is a basic cognitive principle of constructivist theory. In the STDC, teachers are able to see operational illustrations of constructivism supported by technology in classrooms. They are able to have direct experience with new practice of technology integration.
- Collaborative reflection; this is where teachers should work in collaborative relationships with colleagues as '... collaborative reflection groups can provide both the direction for individual change efforts ...' (Hasseler & Collins, 1993, p. 11). The STDC recognises the importance of teacher reflection in its basic objectives and provides collaborative contexts through regular structured discussion as well as informal sharing.
- Long-term collegial interaction; the learning gained by individual teachers is not likely to be translated into reformed practice without long-term collegial interaction. Collaborative support greatly increases the likelihood that changes in practice will be sustained. The STDC provides a basis for collegial support by encouraging teachers to continue their interactions beyond the program through personal contact and email,

> also by offering the 3-day seminar as an opportunity to return for additional sharing and support. Carney concludes that the STDC helped teachers integrate technology into a context of standards-based curriculum, constructivist pedagogy and authentic assessment.

Further research (Hruskocy et al, 2000) suggests that training school students to serve as technology experts may aid integration of computers into the classroom setting. Ten teachers of grades one through five were required to send their pupils to the training sessions. Evaluation data to determine the strengths and limitations of the programmes were collected through reflection papers prepared by each member of the university team. The strengths of the programme showed that teachers were observed becoming more frequent users of technology, expressing a greater desire to learn along with their students. Teachers became more curious about their students' expanding computer skills and enthusiasm and lost their reluctance to ask questions. In the end, teachers began to use their students' expertise to increase their own computer skills. Teachers also observed changes in students' ease of use with technology. Students' skills were transferred to the classroom, and teachers become more motivated to learn to use technology and to incorporate technology in classroom activities. The limitations of the training session mainly centred on the limited time in sessions to practise. Hruskocy et al concluded that teachers' expertise and dedication are necessary for technology integration to occur and students' enthusiasm and talent prompt the process to unfold.

Other studies further revealed positive factors which encourage teachers to use technology: collegiality among computer-using teachers at their school, school support for consequential computer activities, resources for staff development, smaller class sizes and more formal computer training (Becker, 1994). Hadley & Sheingold's (1993) work reinforces that there are many different factors involved in different teachers' road to success. However, these qualitative findings do not yield insight into the individual teacher's learning process, including both the cognitive understanding of technology and teaching and the sociocultural factors that have an impact on such success.

McFarlane (1999), in a study of the introduction of integrated learning systems (ILS) into schools, also found improved teacher attitudes and use of computers. Clariana (1992) suggests five stages of teacher participation in the implementation of ILS, which built on the model proposed by Schnitz & Azbell in 1990. These are:

- novice non-participatory, where a teacher drops off a class at the ILS laboratory;
- novice participatory, where the teacher attends the classes but does not know the ILS;
- practitioner, where the teacher uses the ILS progress reports to help pupils by remediation or re-teaching;

- integrator, who manipulates the ILS sequence so that it better matches the classroom instruction;
- extender, who has fully integrated the ILS into classroom curricula.

This model may be helpful in looking at the integration of other forms of educational software into the curriculum.

Goodwyn et al (1997) found that the majority of student teachers and about half of serving teachers of English in the UK now welcome ICT in English and see it as central to the literacy of all pupils. Willis (1996) argued that this integration of computers into the classrooms is a complex process that involves personal, group, organisational, institutional and even cultural change. The study by Goodwyn et al involved following and interviewing a group of 20 English student teachers and qualified English teachers. It was found that the teachers could be grouped into three distinct categories: 'the fearful' represent those usually older teachers for whom ICT is generally a threat and the cause of much anxiety. As a percentage they might represent approximately 16% of all English teachers. The second group, 'the unresolved' represent 32% of English teachers: those who are changing and redefining their concept of literacy but who have strong mixed feelings. In the third group are 'the optimists' who can be categorised as pro ICT. They would represent 50% of English teachers, and believe that ICT can significantly enhance English teaching.

Pedretti et al (1999) conducted a qualitative case study of the professional development of two teachers involved in a collaborative effort to advance technology implementation in high school science classrooms. The *TESSI* (Technology Enhanced Secondary Science Instruction) project involved researchers observing classroom teaching and learning episodes, conducting student questionnaires and interviewing the teachers about technology adoption and integration, instructional strategies and pedagogical beliefs. The *TESSI* project originated with two classroom science and physics teachers from different schools in the same district. Researchers joined the project to contribute to and extend the exploration of the evolving technological classrooms. Central to the process of change was the group's belief that technology should not be regarded as a substitute for teachers, but rather as a means of enhancing and transforming instructional practice. The teachers integrated technologies incrementally into their programmes, courses and curricula. Time previously spent on teacher talk was gradually replaced with practices that promoted student use of a range of multimedia technologies including: (a) software-generated simulations to develop and extend understanding of science concepts; (b) laserdiscs and videos; (c) computer-interfaced probes/sensors in laboratory situations to collect data; (d) computer applications to process and analyse lab data; (e) presentation software to present information; (f) interactive testing programs to assess learning; and (g) software for recording marks. Each new addition of multimedia technology required negotiation, collaborative decision making and curriculum adaptation. Pedretti et al

concluded that the case study of *TESSI* confirms that the integration of technology in classrooms can significantly transform teaching and learning. The evolution and continuation of *TESSI* illustrate that long-term personal and professional commitment and collaboration among teachers and researchers are integral parts of this transformation.

The Role of the Teacher in Relation to ICT and its Effect on Pedagogy

Recent research into pedagogy and ICT in the UK was carried out by Moseley & Higgins (1999). It focused upon the teaching of numeracy and literacy in primary schools using ICT. The research drew upon school improvement methodologies and made use of a model of teaching and learning. The model regards pedagogy as being about teachers' behaviours in the classroom. An important factor determining teachers' behaviours, according to the model, is Pedagogical Content Knowledge, which is defined as 'the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organised, represented and adapted to the diverse interests and abilities of learners, and presented for instruction' (p. 10). Further characteristics of teaching and learning contained in the model come from the learners themselves and the context of the teaching and learning process. How ICT fits into this model depends upon whether teachers see ICT as changing the nature of their subject and the way it is understood, or whether ICT is seen as a tool for teaching another artefact in the classroom. Moseley & Higgins studied the attitudes of a small sample of teachers. They found that teachers who successfully made use of ICT had the following characteristics:

- A positive rather than negative attitude towards ICT. Teachers who have positive attitudes towards ICT itself will be positively disposed towards using it in the classroom.
- Pupil choice rather than teacher direction. Teachers who preferred directive styles of teaching tended to rate their own competence as low and made use of helpers with ICT.
- Pupil empowerment as learners rather than pupils receiving instruction.
- A preference for individual study rather than pupils receiving instruction.

Bruner (1996) claims that all teachers have theories about how their students learn, which informs their approach to teaching. Bruner's four models of pedagogy are: (1) the acquisition of 'know how', where children are imitative learners; (2) the acquisition of propositional knowledge, where children learn from didactic exposure; (3) the development of intersubjective interchange, where children are thinkers; and (4) the management of 'objective knowledge', where children are knowledgeable. It is possible to see pedagogies involving ICT in all four of these models. Heppell's (1993) stages of development from Topicality to Surrogacy (where ICT is a

replacement for the teacher) through to Progression (where ICT is an exploratory tool) and Pedagogical Change (where ICT is an agent of change in both what is learnt and how it is learnt) reflect these pedagogies. Integrated Learning Systems would, for example, fit into his Surrogacy stage and also be an example of Bruner's second model. Research on ILS indicates that the role of the teacher is crucial to its success (McFarlane, 1999). There has been extensive research into collaborative and cooperative learning with ICT (for example, Hoyles et al, 1994) in which groups of learners solve problems or carry out learning tasks with the aid of a computer. This research is based on constructivist theories of learning, much as described in Bruner's third model.

Olson (1981) developed the idea that the computer offers teachers ways to enhance what and how they teach, but at the same time threatens those very practices by calling them into question. The very presence of the computer says something about what the teacher values, it symbolises the teacher's interest in modern trends and her capacity to cope with the latest teaching technologies. However, the computer also threatens illusions which teachers have about what they are doing (Solomon, 1986; Watson, 1987). Some think computers make better teachers; others imagine that computers help teachers do what they do better.

Olson further adds that teachers act to protect their influence over core elements of their work, such as covering the curriculum and maintaining their credibility. However, these protective strategies for maintaining classroom influence may erode the potential of computer-based teaching. Achieving the full benefits of computers in the classroom may require the teacher under observation to tolerate more ambiguity, to increase individual attention, and to engage students in divergent thinking. All of these create risks. These risks are managed, but overprotection of these core elements may set a limit to reform of the curriculum through computer-based teaching unless teachers and software designers look critically at the way teachers exercise influence in the classroom. Cuban's (1993) work referred to earlier is testament to this risk management.

Scrimshaw (1997) examines the teacher's role in classrooms with computers. He argues that teachers need to teach the process of learning rather than its products. The conventional learning skills, such as locating, collating and summarising information, and identifying connections and contradictions within a body of information, all need to be explicitly moved to the centre of the curriculum. The development of such skills needs to be supported using appropriate forms of software. This requires the explicit teaching of ways of organising cooperative activities involving computers, whether in face-to-face groups around a single machine, or through cooperation at a distance via a conferencing or email system. In order to do this, teachers themselves need more opportunities and support in using the new technologies in collaborative contexts, so that they can both identify the problems and possibilities for themselves, and find ways to model these

activities in their own practice with learners. Finally, when introducing these newer technologies teachers too need time to reflect upon and research what is happening.

Studies of Teachers Learning to Integrate Technology into Their Teaching

McDougall & Squires (1997) argue that the Perspectives Interactions Paradigm, designed for educational software assessment, can further provide an organising framework for thinking about teacher professional development and for structuring evaluative thinking in the use of IT. McDougall & Squires consider a set of five commonly observed foci for teacher professional development activities in the IT area. Focus 1 examines skills in using particular software applications. These activities aim to develop teachers' skills in using specific software packages or applications, such as word processors, an operating system, or Internet access software. Focus 2 examines integration of IT in existing curricula. These activities focus on the integration of the use of technology into the curriculum with which a teacher is working. Focus 3 examines IT-related changes in curricula. The use of IT in educational contexts has opened up many possibilities for curriculum change; often these reflect IT-related changes in the nature of disciplines. Focus 4 examines changes in teacher roles. IT in classrooms can be associated with significant changes in classroom climate, and teacher and student roles in learning; for example, groupwork and collaborative learning activities can be enhanced when IT is used. Focus 5 examines underpinning theories of education. Opportunities for such sustained examination and reflection on the underpinning principles in education are most typically provided by teachers through enrolment in formal courses.

McDougall & Squires then go on to locate each of the above foci in the framework provided by the Perspectives Interactions Paradigm. Consideration of the interaction between the perspectives of the designer and the teacher raises issues related to explicit, implicit or even absent curriculum considerations in the use of IT. When explicit links to a syllabus are made, activities will naturally be seen as fitting into the existing curriculum rather than changing it. Professional development activities with the first three foci outlined above can be thought about in terms of this perspectives interaction. The teacher-student perspectives interaction explicitly raises issues related to the learning situation. A consideration of changes in the distribution of responsibility for teaching and learning between the teacher and student(s) is implied. In this context, classroom teachers can be regarded as managers and supporters, as opposed to directors of student-focused activities. Collaboration between peers, particularly in small groups, often becomes very important when IT is used (Hoyles et al, 1994). Such changes in classroom environments clearly have

implications for teacher professional development, and professional development activities focused on changes in teacher roles, as in the fourth focus listed above, can be linked to this perspectives interaction. The interaction between the designer's and student's perspectives enables the raising of issues relating to ways in which the use of IT-related activities can aid learning. This perspectives interaction is essentially concerned with the theory of learning that underpins the use of an IT application, and implies a knowledge and understanding of cognition. Professional development activities on issues related to this perspectives interaction would be included in the fifth focus. The framework was applied to a school-based professional development programme in an Australian school with a policy to integrate IT use across both primary and secondary classes. McDougall & Squires conclude that such a programme does provide 'an approach to IT professional development that is both authentic and comprehensive' and conclude that 'such programmes should be school-focused'.

Davis (1997), using McDougall & Squires's Perspective Interactions Paradigm, reflected on professional development for IT in a wide range of contexts. Davis found that there were a further two foci that needed to be added to the list of five: changes in the manager role and evaluation of development and this framework. Davis suggests that the addition of a focus to the framework should be changes in the management of IT in the learning environment. Without the professional development of senior managers, including head teachers, any framework will be unable to hold its structure against stresses imposed by traditional educational organisations. McDougall & Squires' case study operated within a benevolent ethos and supportive management, but others will need to work towards such an ideal. Davis further points out that an evaluation framework for teacher professional development should itself have an evaluation focus to feed back information into our knowledge of teacher professional development. Davis concludes that the framework may well apply beyond IT to any innovation in education.

Persichitte & Bauer (1996) addressed the instructional design process which was utilised for the development and delivery of one successful teacher technology training effort for a medium-sized school district. The theory of instructional systems design guided the creation of teaching materials. The theory involves the application of principles from fields such as behaviourism, information processing theory and cognitive science to the design, development and evaluation of teaching resources. The second theoretical framework used was Hall & Hord's (1987) Concerns Based Adoption Model or CBAM. This is a model of how the adoption of innovations occurs in education. The Northern Colorado project described by Persichitte & Bauer has a number of unique features. The program does prepare and support teachers to technology in the classroom, but it also provides training for others from pre-kindergarten aides and food service employees to school board members.

The third area of research focuses on analysis of teacher learning and use of technology in the classroom, in technology-rich and support-rich environments. Stager's intervention (1995a; 1995b) in a technology-rich Australian school district was comprised of three distinct practices: (a) in-classroom assistance; (b) 3-day off-site program; and (c) 2-day off-site problem-solving sessions. 'Trainers' (who were successful technology integrators and classroom teachers) worked inside teachers' classrooms to observe, evaluate, model, and answer questions about integrated use of technology. Off-site meetings offered time for peer collaboration, personal reflection, and renewal of enthusiasm for learning about technology, or focused on collaborative peer work on and sharing of problems. Stager highlighted the importance of both on-site (use of familiar computers/software) and off-site (reduction of school pressures) professional development, adequate technology support and maintenance, financial assistance for teacher purchases of computers, and support for in-school sabbaticals.

Somekh, (1991) in the Pupil Autonomy in Learning with Microcomputers (PALM) project, used action research as a strategy for creating and sustaining teachers' motivation, thereby supporting their development of both technical and higher-level computer skills. Teachers were asked to experiment with computer use in their classrooms, in order to research their educational potential. The strategy proved very successful. The majority of teachers who worked with PALM had few computer skills when they joined the project and by the end counted themselves as confident if not highly proficient users. PALM provided a considerable amount of on-the-job support through the three full-time project officers. Once motivated to their own development, participating teachers were provided with both educational and technical back-up. They also had access to some financial resources. The theory of 'situated cognition' (Brown et al, 1989) helps to explain the usefulness of action research as a strategy for teachers' learning in PALM, since they acquired most of their higher-level computer skills, and many of their technical skills in the classroom, working alongside their pupils.

Another widely acclaimed research programme (Dwyer et al, 1991; Sandholtz et al, 1997) focused on technology-rich, nationwide Apple Classrooms of Tomorrow (ACOT) supplied with 'computers, printers, scanners, laser disc, and videotape players, modems, CD-ROM drives and hundreds of software titles' (Dwyer et al, 1991). Intervention aimed at helping teachers learn to teach in a technology-rich context, supported by researchers and ACOT staff who managed software and hardware training, planning and sharing time, and offered peer observations. This longitudinal research program identified an instructional evolution through which teachers progressed during their (usually 5-year) technology learning process. They moved through the Entry phase, where instruction remained primarily unchanged and teachers grappled with technical problems. During

the Adoption phase, teachers began using technology in their classrooms, though most 'incorporated computer-based activities aimed primarily at teaching children how to use the technology' (Sandholtz et al, 1997, p. 38). From this, and still within the Adoption phase, teachers integrated technology into their classroom practice, which increased student productivity. In the Adoption stage, teachers' own personal attitudes changed so that they mastered certain types of computer-related technologies, increasing their self-confidence. Finally, during the Invention phase 'teachers experimented with new instructional patterns and ways of relating to students and to other teachers' (Sandholtz et al, 1997, p. 44).

Sepehr & Harris (1995) carried out a small-scale study to explore primary teachers' use of software in supporting pupils' learning. The study used questionnaires for 56 teachers and interviews for nine of those teachers who had responded. The teaching approach used by the teachers was related to the type of software that they used (64 programs were identified). The software was categorised into drill and practice and content-free groups. Sepehr & Harris argued that the 'holistic' and 'active learning' approaches to reading have been closely associated with content-free software and the findings of this study confirm this. The teachers who used whole book approaches to teaching preferred content-free software. The whole book approach represents the 'holistic' and 'active learning' approaches to teaching reading, where children are taught to read whole words rather than words being segmented into phonemes. Teachers preferring structured phonetic approaches preferred drill and practice programs.

In 1996, the British Educational Communications and Technology Agency (Becta) (Youngman & Harrison, 1998) carried out a study that sought to develop teacher competence and confidence in the use of ICT with portable computers. Approximately 1150 teachers in 575 primary and secondary schools were provided with a multimedia portable computer together with two Internet subscriptions, core software and a number of CD-ROM titles. The evaluation of the project made use of three sources of data: the databases which held records on the teachers and their schools, including self-ratings of initial self-confidence and competence with ICT; a detailed questionnaire administered at two points, 3 months and 8 months into the academic year; and case study data. It was found that a very high proportion of teachers (98%) made effective use of their computer; a very high proportion made use of desktop publishing software; over 94% of teachers attempted to use the CD-ROM, and 91% were successful. The use of e-mail (62%) and the Internet (76%) was high. The degree of computer literacy of many teachers increased to the extent that even relatively inexperienced teachers were quickly able to use their computer's power to evaluate a variety of software packages, and to filter, import and export information in order to better suit their own curriculum purposes. Teachers' confidence and competence changed for the better; they felt that their

knowledge of IT had increased 'substantially', teachers changed their ways of working and their enthusiasm for their work increased. The most significant benefit to pupils was indirect, through the teachers' more expert use of tools for creating high-quality classroom materials and improved access to resources.

The study showed that four conditions contributed to the success of the project:

- Initial and immediate success with the technology through the hands-on demonstration and the provision of user-friendly hardware and software.
- Personal ownership and exclusive use of a machine over an extended period.
- The portability of the equipment so it could be moved between work areas and between home and school.
- Formal and informal support – the combination of the ownership and portability provided teachers with a greater variety of support from peers and other sources.

It was concluded that this Multimedia Portables for Teachers Pilot was very successful in leading to a significant enhancement of the ICT skills of the great majority of teachers who took part. Similar findings were discovered by Selinger in a study of the effect of the loan of computers on 1000 students studying at a distance on a part-time initial teacher education course at the UK Open University (Selinger, 1996). It may be important to note that the study did not report any significant correlation with teachers' use of ICT in the classroom.

Willis et al (1999) carried out a review of current research on information technology in teacher education (ITTE). Willis et al argue that ITTE research can be categorised into three paradigms: empirical, critical and interpretive. Survey research of Becker provides examples of empirical research that have made a major contribution to ITTE and have accurately portrayed the situation of computer use in schools (Becker, 1994; 1999). His research provided valuable information about the changing classroom practices related to computers. Critical theory brings to light the inequities that are inherent in modern capitalist societies. Apple (1993;1991) discussed in detail whether the teaching profession will be enhanced by the advent of technology. He concluded that if current research trends continue, the profession will be disempowered and de-skilled as teaching is redefined as a management job that focuses on keeping the computers running while the machines deliver specific, skills-based instruction to students who are being prepared for boring, demeaning jobs in a capitalist society that views people as resources to be used as the employer sees fit. Monke (1997) used a detailed case study of the diffusion of technology into the public schools of Des Moines, Iowa to highlight the significant and serious hidden costs to teachers and administrators. A critical perspective was also used by Chisholm & Wetzel (1998) to evaluate computer-supported lessons created

by a group of elementary teachers. They found the lessons strong on integration, with a focus on high-level thinking skills.

The third research paradigm for ITTE is interpretivism. This is related to forms of research that are often described as qualitative. Much more emphasis is on understanding the context of research since much of the meaning is in the context. An example of an interpretivist approach is the work of Norum (1997), who reported observations of two high school teachers who were learning to use a television-based distance education system to deliver foreign language instruction to students in several different schools in the Denver area. Norum used case study methodology but reported the case studies in the format of a non-fictional education story. Using a mutiparadigmatic approach, Willis et al draw together the main threads of what the research tells us today; for example, that teachers have very positive attitudes towards the use of technology in education, but are far less confident about their ability to actually use the technology and do not think that their teacher training programmes prepared them to use technology in innovative ways. Also, that teacher training faculties, although positive about IT, do not have a strong background in integrating that into teacher education courses they teach.

Willis et al conclude that there are isolated examples of 'islands of excellence' that illustrate what can be done in ITTE. The diffusion rate is slow and a major focal point for ITTE research could be on the process of change and diffusion. More detailed case studies on the process of change, how it is handled and how it occurs are needed. More case studies on diffusion of innovations are needed, how they were created and how they will be disseminated so that other teacher education programmes can use them if they wish. Also, more reports are needed from the teachers who were involved in integrating the innovation into their classroom. More bias-related findings in terms of gender, social class and ethnic background use of ICT are needed from critical theory research as well as ways of readdressing the balance. There also needs to be more development and dissemination of resources and tools for using technology effectively in teacher education. Recommendations for further work in this area also include reports on the instructional design process that lead to the creation of innovations.

Discussion and Conclusions

The review has brought to light three interlocking factors that affect teachers' take-up of ICT. These are institution, resources and the teacher. The school as an institution gives little time to teachers to manage and familiarise themselves with ICT (Robertson et al, 1996). Due to pressures of work inside and outside the classroom, timetabling does not allow time for such learning. As well as lack of time, schools provide no supportive network for teachers who are not confident enough to take up ICT (Rosen

& Weil, 1995; Winnans & Brown, 1992; Dupagne & Krendl, 1992; Hadley & Sheingold, 1993). Thus, schools seem to be slow in embracing ICT, and there is a resistance to change (Fullan, 1991; Cuban, 1993). This resistance is based on an unclear understanding of what change should constitute and the reasons why changes should take place in the first place. This leads to confusion and misunderstanding. Schools do not feel a need to change, they are content with their familiar tried and tested ways of teaching. As Cuban claims, schools are firmly grounded in cultural beliefs about the student-teacher and not student-machine relationship and this dominates schooling. Thus, there is little scope for opportunities to adapt to technologies. However, Dawes (1999) argues that teachers are welcoming of the changes computers bring, and do make changes and choices in the materials they are asked to use on a regular basis. Thus, the term 'resistance' is stereotypical and shows ignorance of the work teachers do in schools. Further recent research (Davis, 1999) suggests particular schools are already changing to respond to their communities' need for ICT training. Similar to other organisations, schools recognise the pervasive nature of ICT and grow to accommodate the changes. Stager's (1995a; 1995b) successful intervention showed the kind of changes that need to be undertaken in schools for effective computer integration in the classroom. These included classroom assistance by trainers who were successful technology integrators, and working alongside teachers to observe, support, evaluate and model computer integration. The school also offered a reduction in school pressures by offering off-site programs which focused on collaboration, personal reflection, sharing problems, sharing enthusiasm for learning with computers and financial assistance to help teachers purchase computers. With such effective school practices, teachers can comfortably progress towards technology-rich environments. Similar findings have been reported by ACOT's intervention (Dwyer et al, 1991; Sandholtz et al, 1997), which helped teachers learn to teach with technology supported by researchers and ACOT staff.

Limited resources within schools are a great impediment to the take-up of ICT. Lack of computers and software in the classroom can seriously limit what teachers are able to do with ICT. Limited resources results in lack of computer integration, which in turn results in lack of sufficient computer experience for both pupils and teachers (Rosen & Weil, 1995; Winnans & Brown, 1992; Dupagne & Krendl, 1992; Hadley & Sheingold, 1993). Teachers need to be provided with adequate facilities and training to be able to use those facilities in order to progress in a technology-rich context. Case studies reflecting successful computer integration have all shown the schools to be provided with excellent facilities, technical back-up and financial resources (Becker, 1994; Hadley & Sheingold, 1993; Stager, 1995a; Stager, 1995b; Somekh, 1991; Dwyer et al, 1991; Youngman & Harrison, 1998; Persichitte & Bauer, 1996; McDougall & Squires, 1997).

On a personal level, there are many factors teachers face that influence their take-up of ICT. Veen (1993) showed that teacher factors far outweighed the institutional or school factors. Despite essential technical support provided by the school and a positive attitude to IT from the school principal, the teacher factors that involved beliefs about the way the subject should be taught and skills associated with competence in managing classroom activities and computer-handling technical skills were the most influential in teachers' use of computers. Clearly, schools can go only so far to encourage ICT use; actual take-up depends largely on teachers' personal feelings, skills and attitudes to IT in general. Research shows that teachers who have a high value for ICT and perceive it to be useful completely transform their teaching (Cox et al, 1999; Pedretti et al, 1999). Similarly, those teachers who are motivated and have strong commitments to their pupils' learning and their own professional development will evidently integrate computers more easily within their teaching (Becker & Riel, 2000; Becker, 1994; Hadley & Sheingold, 1993; Sheingold & Hadley, 1990). Moseley & Higgins (1999) further found that teachers who successfully use technology in the classroom have positive attitudes to ICT and focus on pupil choice and individual study rather than teacher direction. School assistance in terms of support, finance, training and facilities are further factors on the road to computer integration. However, teachers vary in their perceptions and experiences of ICT, and so their uptake depends on a range of combining factors. Carney (1998), however, found four factors that were common to exemplary computer-using teachers: challenges to frames of reference, situated learning, collaborative reflection and long-term collegial interaction. These combined factors helped teachers to integrate technology. Another factor that has shown to impact on teachers' integration of computers in the classroom was students' expertise in computer use (Hruskocy et al, 2000).

The range of software that is available for subject teachers also encourages some teachers to take up ICT (Goodwyn et al, 1997; Clariana, 1992; Scrimshaw, 1997; Sepehr & Harris, 1995). It could be that teachers are able to match what they teach and how they teach it with appropriate software, as Veen's (1993) work has shown. If this is the case then software designers and teachers should work together and observe critically how a range of teachers teach in the classroom and how appropriate forms of software supporting different skills and ways of teaching and learning can be better developed for teachers to use in subject teaching. This is further highlighted by McDougall & Squires (1997) in the perspectives of the designer and teacher. The two need to consider the curriculum considerations in the use of IT as well as devise innovative and imaginative IT-related activities.

These three areas of research on teachers' learning and use of ICT in the classroom yield interesting information about barriers teachers face, factors involved in supporting high technology use and the paths teachers

follow when learning to use technology. The implications of the studies are that teachers' theories about teaching are central in influencing teachers to use ICT in their teaching. Even if teachers are provided with up-to-date technology and supportive networks, they may not be enthusiastic enough to use it in the classroom. Teachers need to be given the evidence that ICT can make their lessons more interesting, easier, more fun for them and their pupils, more enjoyable and more motivating. Clearly, as Willis et al argue, more case studies are needed that bring to light innovations in the use of technology that have been implemented and studied over several years.

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Correspondence

Shazia Mumtaz, Woodmere Apartments, 8200 Henry Avenue, Philadelphia, PA 19128, USA.

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Forthcoming Conferences

2002 ITTE Research Conference, 9th-10th February 2002
Møller Centre, Churchill College, Cambridge, United Kingdom
www.itte.org.uk

Held every 18 months in Cambridge, this conference provides a small (around 50 delegates) and supportive environment for sharing and exploring relevant research themes. New researchers are positively encouraged to contribute. The conference will include two keynote speakers who are prominent in the field. Bursaries covering 50% of the seminar costs are available to research students.

SITE 2002, 13th International Conference, 18th-23rd March 2002
Nashville, Tennessee, USA
www.aace.org/conf/site/

The annual *Society for Information Technology and Teacher Education* conference offers opportunities to share ideas and expertise on all topics related to the use of information technology in teacher education and instruction about information technology for all disciplines in preservice, inservice, and graduate teacher education as well as faculty and staff development.

Ed-Media 2002, 24th-29th June 2002
Denver, Colorado, USA
www.aace.org/conf/edmedia

The scope of the conference includes, but is not limited to, the following major topics as they relate to the educational and developmental aspects of multimedia/hypermedia and telecommunications: Infrastructure; Tools & Content-orientated Applications; New Roles of the Instructor & Learner; Human-computer Interaction (HCI/CHI); Cases and Projects; Universal Web Accessibility.

e-Learn 2002, 15th-19th October 2002
Montreal, Canada
www.aace.org/conf

The scope of the conference includes, E-Learning (Corporate, Government, Healthcare, & Higher Education); WebNet Symposium Topics; Universal Web Accessibility Symposium Topics. A full list of the topics can be found on the conference website.