ENABLING TEACHERS TO MAKE SUCCESSFUL USE OF ICT

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Executive Summary

Introduction
This literature review seeks to identify the factors which are most effective in enabling and encouraging the uptake of ICT by teachers. It is a continuation of the work begun by Becta in a companion report, looking at the barriers that exist in schools which prevent teachers from making full use of ICT in their work (Becta 2004). The report aims to discover from the literature the recommendations that might assist schools and local and national support agencies to help teachers make better use of ICT in their classrooms.

Survey of practitioners
To support the evidence from the literature and to ascertain the views of teachers, lecturers and head teachers on this subject, a small scale survey of practitioners was conducted, and the results of this are presented in the report. The survey was conducted on-line; visitors to the Becta Research website were invited to list the factors which most enabled them to integrate ICT in their teaching. Although the survey was based on an unrepresentative sample, it gives a picture of the sorts of enabling factors that teachers and head teachers saw as the most significant.

Literature Review
The findings from the survey give a reference point for reviewing the research literature, and the key points identified from this review can be summarised as follows:

- Much of the reviewed literature appears to be concerned with evaluating the introduction and use of ICT in schools in terms of the contribution it makes to 'student-centred' teaching and learning. However, Gibson (2001) observes that the majority of teachers tend to prefer to use a variation of the 'teacher-centred' model. This means that for these teachers to make full use of ICT in their work it is necessary for them to make radical changes to the way they teach (Fabry and Higgs, 1997).

- It is suggested that while there are school level factors that are at present unfavourable to the greater spread of student-centred uses of ICT, these are open to change. This report therefore seeks to investigate the literature in order to discover what such changes involve, and how they might be brought about.

- The personal characteristics of teachers may also be an important influence on the extent to which they take up an innovation, such as the implementation of ICT. This may result in the need for different approaches to ICT implementation for different teachers.

- Ertmer *et al*. (1999) identified three levels of teachers' computer use, varying in their relationship to the existing curricula. These involve using

ICT as: (1) a supplement to the curriculum, (2) a reinforcement or enrichment of the curriculum, or (3) a facilitator for an emerging curriculum. The authors suggest that training provision should be systematically differentiated to meet the needs of teachers at each of these levels.

▪ In addition to the need for individual teachers to make personal changes in order to make more widespread use of ICT (teacher level factors), there also exists a range of school level factors which can inhibit its use. It is therefore necessary to investigate the ways in which both teacher level and school level factors can be addressed in order to increase ICT use.

▪ In suggesting strategies for supporting teacher development in the use of ICT, the literature organises these into two main areas: school-based and externally supported strategies, and these are addressed in turn:

School based strategies
The literature suggests a number of ways in which schools working independently can make successful classroom use of ICT more likely. These include the following points:

–   The role of school leadership is central in enabling teachers to engage in innovative practice.

–   Planning is also seen as an important factor, and three elements of planning are picked out by the literature: the need for the creation of a vision statement; the importance of needs assessment; and the need for a school development plan.

–   A whole-school approach to access to and sharing of resources appears to be preferable. Appropriate resourcing and flexible, forward-looking planning, linked closely to what teachers actually want and need at any given stage, will be essential.

–   Many of the sources point out the significance of professional development. A variety of approaches may be taken, and it is suggested that a combination of approaches are needed to suit the level of progress that staff individually and as a whole have already reached.

–   Reliable technical support in schools is also recommended by the literature, although there are several ways in which schools might approach this. Whichever approach is used there is a need for coordination to ensure that the support is effective.

External enabling strategies
There are many examples in the literature that demonstrate ways in which schools can draw on outside support to improve their use of ICT. These include the following points:

– Working more closely with the local community has allowed some schools to move further towards student-centred use of ICT. Such links, it is argued, enable the development of a more authentic and contextualised approach to learning, which can be supported by ICT tools.

– Schools working with other local schools have found this to be a useful way to identify successful practice and to sustain teachers' motivation.

– External support may also be provided in the form of locally based training. Ross *et al*. (1999) highlight the advantages of involving teachers in the design of such training courses, providing training differentiated by teacher expertise, and in the form of continuous professional development rather than "up-front" sessions.

– Participation in national ICT developments, projects and initiatives can also be helpful in promoting ICT use, as ICT leaders are able to gain knowledge from the multiple training and educational experiences provided by these initiatives.

– Teachers may gain support in linking with their peers both within and outside their local community, through the use of electronic networks and forums. These benefit teachers by providing opportunities for the dissemination of good practice, development of confidence and motivation, and better access to resources and research.

– It is suggested that success depends on combining different activities within a clearly conceived overall strategy, rather than adopting one specific approach to ICT integration.

Analysis of results
▪ Potential mismatches are identified between the relative positions of a school and its teachers on the scale of ICT development. The extent to which individual teachers are committed to integrating ICT, and how this commitment relates to that of the school as a whole, can have a significant impact on the degree to which ICT can be integrated by those teachers.

▪ The literature reviewed for this report raises a number of questions which arguably need further investigation:

1. What are the likely indicators that a school is near to making the move from one level of ICT integration to the next? For schools that are at such a transition point what are the key factors that affect whether or not they make the transition successfully?

2. Where only a small minority of staff are innovating with ICT what kinds of support are needed to ensure that they continue to do this? What is needed to enable the innovation to "break out" of this small group and be taken up more widely within the school?

3. What examples are there of highly innovative schools successfully using ICT mainly to reinforce their existing teaching and learning practices rather than to change them? How did they reach this position? In what ways do they maintain their innovativeness and what can other innovative schools learn from their experiences?

4. What positive roles (if any) have ICT-based innovations played within successful strategies for turning round failing schools?

5. In what ways are highly innovative schools cooperating on ICT-based innovation with others that are less far forward in their use of ICT? What difficulties do such partnerships encounter and how are they being overcome?

Introduction

This document is published in conjunction with a companion report (Becta, 2004) on the barriers that exist in schools that prevent teachers from making full use of ICT in their work. That report brought together the findings from a number of earlier Becta documents with evidence from a literature review of the more recent research that had been carried on the topic of barriers to teachers' ICT use.

The brief for this review was to take that investigation further by reviewing the literature on implementation, and to identify the factors which are most effective in overcoming these barriers and encouraging the uptake of ICT by teachers. It sets out therefore to pick out from the literature the recommendations that might assist schools and local and national support agencies to help teachers make better use of ICT in their classrooms. In addition Becta carried out a small survey (see Appendix B) to provide very up to date evidence of the current views of teachers and heads on these matters.

Sections A to C are a descriptive analysis of the evidence and findings in the sources, while Section D offers an interpretation of these, together with recommendations that emerge from that interpretation.

Methodology

In order to identify the available research evidence for this review, Becta carried out a literature search in August 2003. This was then updated in January 2004 in order to include the most recent literature. The sources and search terms used are given in Appendix A. The external reviewer responsible for preparing this report then double-checked the documents provided and selected out those to be discussed in the report. This involved excluding those judged to have insufficient direct relevance to the topic and those which, while making recommendations, offered only very brief general proposals that essentially overlapped with other more detailed sources. Others which essentially recommend things already implemented in the United Kingdom were also excluded. This gave a final set of 42 sources. In addition a standard general text on innovation (Rogers, 1995) was included to provide an explicit link with some key findings and concepts from the more general research on innovation.

Most of the texts report experiences in the UK and the United States, but evidence is also included from Australia, Canada, Denmark, France, Greece, Israel and the Netherlands. The sources deal with a wide range of cultural and organisational contexts, cover teachers and schools at different points in the introduction of ICT and were published over a ten-year period which means that the technological context also varies significantly. The approach therefore has been to provide an analytical framework that brings out the main dimensions of the problem, and then to provide in as concrete a form as possible the sorts of enabling strategies that have been recommended by the authors. It is then for each reader to identify what possibilities this suggests in his or her own situation. In the interests of clarity any references to other

sources within the quotations have been silently removed; they can of course be followed up through the original sources.

The method of analysis used was to review the texts to locate material that would help either to conceptualise what was involved in enabling successful use of ICT, or that provided specific recommendations about, or illustrations of, ways of achieving this. This material was coded initially in terms of its match to the barriers identified in the earlier Becta report. However what emerged was that many of the strategies used were designed to overcome a number of the barriers simultaneously. The material was therefore recoded into the broad action guiding categories that are reflected in the headings of Sections A to C below. Sub coding was then used within each category to provide the main sub divisions used in each section.

Section A: Successful Use of ICT: what kind of innovation is it?

This section provides a framework for the following sections on methods of implementation. It opens with the results of a recent teacher survey on the use of ICT and then suggests that we are here concerned with an innovation both in technology and teaching, with a strong focus upon using ICT to promote student-centred approaches to teaching and learning. The reasons suggested for the relatively low take up of this innovation are then discussed, and a developmental model for the introduction of the innovation presented.

An innovation in technology, teaching methods or both?

As part of its work on ICT barriers and enablers Becta carried out a survey of visitors to the Becta Research website, to gather views on what factors most encouraged teachers to make regular integrated use of ICT in their classrooms. While this was no doubt a highly unrepresentative sample,, it did give an up to date picture of the sorts of enabling factors that teachers, heads and others with an interest in this area saw as important and a reference point for reviewing the research literature.

The full results are given in Appendix B, but the most frequent individual factors which enable ICT use, according to the survey participants, were:
- access to own personal laptop
- availability of high quality resources
- full access to software & hardware at all times
- high level of technical support
- access to an interactive whiteboard
- availability of good quality training.

At a whole school level the enablers emphasised were:
- on-site technical support
- programme of staff ICT training / CPD in place
- support / ICT vision from senior management
- whole school policies on using ICT across curriculum

- provision of interactive whiteboards in all classrooms
- effective timetabling of rooms & equipment / access to resources

The additional, extended comments provided by the survey participants fill out and amplify this picture. Many of them can be seen as falling into three categories.

The first group related to **ensuring awareness, capability and confidence in teachers** in relation to using ICT. Comments on this included:
- The most important factor is confidence. Adequate training is needed to allow teachers to feel competent in what they are doing. Observing other teachers in 'real life' situations is very helpful.
- Support - this is vital if diffident staff are to use ICT. I have a flexible timetable which allows me to support non-specialists in the use of the ICT suite or laptops in their classrooms.
- All children are taught ICT. This means that they push teachers into using ICT in other lessons in many cases. Many teachers now have laptop computers and this is developing their own confidence to use ICT with their classes. A wireless network enabling laptop computers across the whole site is also opening up opportunities and teachers are talking about what they would like to do when...

The second group were concerned with **ways of ensuring access as required to reliable systems**:
- Reliable technical backup is really essential. Setting up a lesson with 30 smiling faces is a disaster when the internet is down - or the ISDN lines are - or the system repeatedly crashes.
- Our three ICT rooms and our laptops are all bookable, as are members of the ICT department for lesson or planning support.
- For a Humanities faculty where knowledge of hardware is, at best, limited, it is a security blanket to know that there are technicians available 'on the spot' to remedy hardware failings. This has meant that some teachers with a very negative approach to ICT have been willing to use it.

The third group of comments emphasised the **educational benefits of using ICT**, either through making teaching and learning more effective or by enabling kinds of learning that were not possible before:
- Increasing the amount of hands on time by pupils in science is most beneficial in enthusing pupils in my subject. Also it encourages a degree of independence giving them the opportunity to take control of their own learning and build up their self-confidence and self-esteem.
- An interactive whiteboard is definitely the biggest asset in to ensuring the effective use of ICT in the classroom for science teaching along with a bank of key websites and shared teaching resources. I have passed on over a hundred useful websites to science teachers and non-subject teachers e.g. history, geography, and English websites.

- The excitement of helping children to employ technology in furthering their learning.
- I feel that the use of ICT helps, in many circumstances, to promote a consistent approach to curricular delivery. It can also be more interactive if delivered appropriately and lessons can be altered quickly and stored for retrieval by others without repeating or duplicating workload. ICT complements the delivery of the curriculum elsewhere and should not be seen as the platform that we should all use.
- ICT supports my lesson, it does not direct it.
- NOF training has helped. Whole department emphasis on the use of ICT in enabling more effective teaching. Possibly most important is the realisation that ICT is only a means to providing more effective learning and teaching. Recognition of different learning methods suitable to individual pupils is also imperative.

While these extracts are chosen to separate out different enablers, many responses also emphasise the interrelationships between them, indicating that what is required is an approach that makes a number of changes together:

- Enough planning and preparation time are key to integrating ICT in our day-to-day teaching. Teachers and support staff need sufficient time to get to grips with any new technology. This gives them more confidence to cope when technology sometimes goes wrong. The more familiar they are with any of our equipment the more they will use it. We often plan cross-curricular activities allowing more time to be spent in planning and carrying out the activity itself. The pupils accept technical hitches more readily than grown ups and are often invited to give feedback on new ideas and equipment.
- The employment of an ICT teaching assistant to share the preparation and set up time. This gives staff the confidence to transfer skills and attitudes towards ICT into all areas of the curriculum. [Also important is] good quality software and websites that are closely linked to QCA Schemes of Work and which do not have their own agenda.
- The key word that you used in this question is "integrate." It means to put things together in a meaningful way. To do that ALL of the parts need to be put into place, not just bits and pieces here and there.

That final judgement suggests that what is needed is an integrated approach to using ICT that recognises it as a complex and wide ranging innovation. But what exactly is this innovation? What do the sources see as counting as successful use of ICT?

A recurring contrast drawn in the literature reviewed is between what Gibson (2001) calls teacher-centred and student-centred models of teaching. This distinction reappears under different labels and covers rather different variants throughout the literature, but for simplicity this report will use just these two terms to cover all of the variants. Gibson offers this example of a teacher-centred strategy:

'At James Madison High School in New York City, 10th.grade students (age 15 years), mostly African American and Latino, file into a networked computer lab and find seats at large new monitors and keyboards. […] James Madison is a large school in a middle-income neighborhood, but nearly all the students are poor and working class. Drugs and violence are a recurrent problem. The computer lab, however, is a relative haven: it is quiet here, and as students enter their names into the computer, they find that the software program greets them warmly by name, remembers exactly where they were when they left off the day before with their work, and gently guides them through well-designed exercises in biology, algebra, and American history, praising successful answers and offering patient prompting and another chance - without a hint of judgment - when they miss an answer. The teacher, who monitors the students' individual workstations from a central machine of his own, moves around the room, helping students with technical problems, finding files, and printing. The students work well and mostly silently until the bell rings fifty minutes after they entered the room. In the chaotic context of James Madison, technology is the vehicle of a more individualized, effective - and possibly humane instruction than students might otherwise get.' (Gibson 2001, p.53)

This he contrasts with a student-centered model, as exemplified in the Richmond Academy, a private school in the same town:

'… 9th-graders (age 14 years) file into their social studies classroom and, before class begins, log on to one of six workstations at tables against the walls. They argue noisily about what they are finding as they unearth an archaeological site in ancient Greece. The students have been working on the computer-based archaeology simulation for about 3 weeks, and teams of students are each responsible for excavating one of four separate quadrants of the site. It is a welcome break for the 9th-graders, who in their other classes spend much of their time taking lecture notes and learning to parse sophisticated texts as part of their college-prep curriculum. Here they are 'digging up' pottery shards, fragments of weapons, pieces of masonry, and bits of ancient texts, and trying to identify and interpret each artifact in order to fit it into their emerging picture of the site as a whole. In their research, the students visit local museums, consult reference works on Greek history, art, and architecture, and ask other teachers in the school to help translate texts.' (Gibson, 2001 p.53)

Gibson observes that most teachers use a variation of the teacher-centred model, where the emphasis is upon the presentation of a body of knowledge or a set of skills that students are to learn.

However this weighting is not reflected in the literature reviewed. Where reports and evaluations make clear whether a teacher-centred or student-led model is being developed it is nearly always the latter. So the innovation that most of the authors are concerned with is not the introduction and use of ICT

per se, but its role as a contributor towards a student-centred form of teaching and learning.

For teachers who would like to use a student-centred approach but find it difficult this innovation presents ICT as potential solution to a problem. However for teachers who prefer a more teacher-centred approach the position is very different. As two American authors (Fabry & Higgs, 1997) put it : 'To integrate technology into classroom practice in the manner envisioned by ardent proponents, teachers must make two radical changes- not only must they learn how to use technology, but they must also fundamentally change how they teach."

This raises the question of how widely distributed this innovation already is. A series of major American studies (Becker *et al*., 1999, Becker, 1994, Becker, 2000) give some picture of how far what their authors call exemplary users of ICT appear amongst the teachers surveyed by the team. The 1994 study identified less than 10% in this category, while in a report on the 1998 survey the percentage of exemplary ICT-using teachers varied from 4% to 13% of the totals for teachers working with the various pupil age ranges. A broadly similar picture is reported from France (Guihot, 2001).

A Dutch study (Pelgrum, 2001) used a complex index to identify the degree to which student-led models were used in each country surveyed. The level reported varied considerably from country to country, suggesting that US results cannot be automatically applied in the UK. However the picture presented by the American studies is at least compatible with that from the later UK ImpaCT2 report (Harrison *et al*., 2002). Here pupils were asked how often they used ICT in school for English, maths and science. The percentages reporting use in maths, science or English lessons most weeks or every week varied by age group and subject, from around 24% to 3%. Given that not all of this use would involve student-centred teaching this suggests that UK teachers making heavy and regular use of ICT in student-centred ways are still very much in a minority.

Why have many teachers not yet adopted this innovation?

The question this raises is why an innovation that has been present in schools in some form for around 20 years has not yet reached critical mass. The literature presents four possible explanations; that ICT is seen as incompatible with some teachers' wider educational beliefs, that there may be immovable social obstacles to greater levels of take-up, that there may be powerful but removable obstacles in schools to expansion of use, or finally that the obstacles may be to do with the personal characteristics of some teachers.

Several studies conclude that a willingness to use ICT depends heavily not only upon its usability, but also its perceived usefulness (Cox *et al*., 1999, Lam, 2000, Preston *et al*., 2000, Yuen & Ma, 2002). This implies that if ICT use is seen as integrally linked with a student-centred view of teaching and learning it risks being viewed less positively by those teachers who do not subscribe to that view. This situation will not change unless, and until

experience of using ICT leads teachers to revise their original position on teaching and learning. As one author puts it:

> For any educational innovator it is important to realize that it is not the view of the innovator about the merits of the innovation that matters, but rather it is the view of the teachers about the innovation that is critical. If teachers start using computers for 'drill and practice' only, it is probably because that use fits their 'routines' best. Their learning process should not be disturbed by telling them that doing 'drill and practice' with computers is only a poor application of information technology. Perhaps it will be only after two or three years that teachers can gradually enhance their routines and handle more complex applications of information technology. (Veen, 1993 p.149)

Another possibility is that there could be insuperable social or economic obstacles to wider use that affect whole categories of schools, communities or student intakes, and that cannot be sufficiently countered by any kind of dissemination strategy. However an American survey already mentioned found otherwise:

> One of the most important results of these analyses is that nearly all of the advantages that exemplary teachers have in their working environments - that they teach where many other teachers also use computers, that their districts provide relevant and broad-ranging staff development activities, that they have access to computers at school and have the time to use them personally, and that they teach smaller classes - are extensible to other computer-using teachers. […] Exemplary teachers in our study taught in a representative range of communities, schools, and classrooms; but they taught in schools and districts where resources had been used to nurture and support the kind of teaching practice we classified as exemplary. (Becker, 1994 p.317)

What Becker and his colleagues are suggesting is that while there are school level factors that are at present unfavourable to the greater spread of student-centred uses of ICT, these are open to change. What such changes involve, and how they can be brought about, are major themes in the literature, and will be considered in the next two sections. However another possibility is that personal characteristics of teachers too are an important influence on how easily they take up an innovation.

Support for this is provided by a classic American study of the diffusion of innovations. Rogers (1995) found that innovators are divided into five categories, depending on the stage at which they take up an innovation. The initial innovators typically form the first 2-3 % to take up an innovation, while early adopters make up the next 13-14%. These two groups together might be called the earlier adopters. The figures given above suggest that regular student-centred ICT is probably now established within these two groups, but

unlike less regular ICT use, has not yet established itself amongst teachers more generally.

This is important when looking for ways to encourage further take-up, because Rogers identifies a tendency for there to be distinctive differences in the personality characteristics of earlier and later adopters. As he summarises it, earlier adopters differ from later ones in tending to show (amongst other things) greater empathy, less dogmatism, a greater ability to deal with abstractions, greater rationality, a more favourable attitude towards change, a better ability to cope with uncertainty and risk, a more favourable attitude toward science, less fatalism and higher aspirations.

This characterisation implies a distinctly unfavourable perception of later adopters. However a positive description of later adopters is not hard to provide. Compared to earlier adopters, later adopters could equally well be described as more realistic, steadier in their judgements, with a concrete grip on problems, having a dislike for fads, being less willing to take unnecessary chances, having a preference for being guided by experience and with a more realistic appreciation of possibilities than earlier adopters.

The underlying point is that, leaving aside personal preferences either way, there is a general tendency for earlier and later adopters to be different from one another. This means that dissemination strategies that work with earlier adopters may be less effective, or even counterproductive, with their more hard-to-convince colleagues.

There are also other factors at work that may influence which teachers are early adopters and which come to an innovation later. Gender differences are one. An Education Guardian article (Krechowiecka, 2002) reported that research showed that building confidence was important for women working in a non-traditional area like ICT. An Australian study (Russell & Bradley, 1997) emphasised the importance of professional development activities taking into account the particular needs of, and demands faced by, women teachers, which may make it harder for them to take on this kind of innovation..

Nor does the concept of "the" use of ICT come near to recognising the complexities that lie under that generic term. In a study already mentioned (Becker *et al*., 1999) reported that, for example, American Elementary Grade teachers were found to group into ten distinct clusters, distinguished by software used, frequency of use, objectives for computer use and locations favoured.

The implications of such a variety of different approaches to computer use by teachers for those supporting the innovation are obvious. Furthermore planning and implementation is made harder still by the rate at which new technologies continue to appear (Harris, 1999). Perhaps one reason why introducing ICT into classrooms seems complicated is because it is just that.

In those circumstances it is not surprising that this is an innovation that teachers take up in stages. In an American case study of a small number of primary teachers (Ertmer *et al*., 1999) the researchers identified three levels of computer use, varying in their relationship to the existing curricula. These involved using ICT as:

- a supplement to the curriculum (e.g., during free time or as a reward for completing other assignments)
- a reinforcement or enrichment of the current curriculum
- a facilitator for an emerging curriculum.

There is also an implication that these stages are in some sense sequential. If so, each of Roger's groups of innovators would have to work through them all, but with different starting dates and at different speeds. However Ertmer and her colleagues also observed that teachers were likely to use ICT at more than one level simultaneously, and that a teacher could continue at one level indefinitely given the relative stability of teacher beliefs about classroom practice, and about the use of technology within that practice. In that sense, the teacher-centred model could, as perhaps in Gibson's example, be one that took reinforcement of the existing curricula as the desired end point, rather than merely a stage towards promoting an emerging, student-centred, curriculum.

What Ertmer and her colleagues propose is that training provision be systematically differentiated to meet the needs of teachers at each of these three levels.

They recommend that teachers using ICT as a supplement should have this view challenged, with demonstrations by peers, mentors, or trainers to show how ICT could help teach existing and expanded content. Time to learn skills, preview software, and explore resources would also be essential. The chance to observe and talk with teachers who had already solved similar problems to theirs would be helpful. So too would seeing evidence (from the literature, peers, or students) of meaningful outcomes being achieved.

For teachers using ICT to support and enrich the existing curriculum Ertmer and her colleagues recommend developing a vision for use that went beyond current topics and skills, together with ideas about how to support and manage students' exploration of individual topics. Observing and talking with teachers using problem-solving and application software in both whole and small group contexts was favoured, either through face-to-face meetings or electronic contact. Involvement in internet-based projects is considered useful in determining how to structure higher levels of ICT use, and also how to provide additional excitement and motivation through collaboration.

The study did not include any teachers using ICT to facilitate an emerging curriculum, but Ertmer and her colleagues suggested that teachers at that level would benefit from increased interactions with other teachers, mentors, and even researchers, and should be encouraged to publish and present their experiences at local and national conferences as well as electronically on the

web, as a way of supporting novice users who are struggling with issues they have already overcome or resolved.

Given this diversity of needs, interests and staring points, how can support for teacher development best be organised? The literature provides two sets of answers to this: school-based and externally supported strategies. The next two sections deal with these.

Section B: What school-based enabling strategies support successful use of ICT?

The sources reviewed identify a number of ways in which schools working independently can make successful classroom use of ICT more likely. These cover approaches to:

- leadership and decision making
- whole school planning and implementation of the change
- whole school use and development of resources
- knowledge sharing and training
- roles of technical support staff.

Though dealt with separately, several of the sources emphasised that in practice all these elements need to be dealt with together.

Leadership and decision making

A UK review (Bosley & Moon, 2003) mentions case study research in the UK that identified a number of factors that enable teachers to successfully engage in innovative practice. These were:

- Previous involvement in innovations (ICT and non-ICT based)
- Support at senior management level for implementing new practices and addressing financial implications where appropriate
- Involvement of several members of staff
- A prevailing culture within schools of collaboration and mutual support
- Willingness to take risks, accepting that some ventures will succeed while others may not.

The role of school leadership is clearly central in meeting several of these preconditions. This was investigated in detail in a Canadian study (Sheppard, 2000). This distinguished three different groups of schools, which varied in their success in integrating ICT into teaching and learning.

In the most successful group of schools the leadership was collaborative, supported innovation and risk taking, and included others in decision-making. Teacher pioneers were important, but other teachers were increasingly comfortable using ICT. Morale was generally high in these schools, while teachers, students, and parents were excited about the level of innovation in the school and quite anxious to share their experiences with others.

In moderately successful schools Sheppard found a few pioneer teachers were using ICT themselves to increase learning opportunities but found expanding use more widely a struggle. Morale appeared generally, but not universally, high. Decision-making rested with the administrators even though committees existed. These schools lacked pervasive team leadership with teachers appearing to be waiting for direction from their principals. Despite this, teachers and administrators were generally content with ICT leadership in the school. Some believed that their integration of ICT into teaching and learning compared favourably with neighbouring schools. Others took the opposite view, but blamed lack of progress on external sources such as the district or provincial government. In combination these factors inhibited organisational learning in these schools.

The third group Sheppard describes as the static schools. Here leadership tended to be traditional and hierarchical, and the commonest view of teachers was that the principal was responsible for bringing about change. Any perceived 'backwardness' in ICT was put down to lack of infrastructure, support, or leadership from the school district and government. Restrictive models of school administration, limited expertise, and no apparent stimulant to initiate ICT-related learning inhibited organisational learning in these schools.

An American case study (Dexter *et al*., 2002) paints a similar picture of successful schools and innovative schools. In six such schools Dexter and her colleagues found a strong commitment to, and support for, teachers' individual learning and widespread use of technology with a student-centred approach. "The presence of this need to learn and the supportive conditions to do so appeared to be reciprocal, or mutually supportive, of the development of professional community around technology use." (*ibid*.)

Whole school planning and implementation of the change

Three elements of planning are picked out for particular comment in the sources. One is the creation of a vision statement (Evans, 2002, Fabry & Higgs, 1997). Needs assessment was also valued (Cadiero-Kaplan, 1999, Fabry & Higgs, 1997) to establish both current levels of use of the technology and staff preferences for the future. Classroom teachers, library media specialists, computer lab teachers, parents, students, community and business people, and decision makers were all involved in the assessment. Both contributed to the schools' development plans. These plans were seen as setting directions and priorities, as well as decisions about the deployment of learning support assistants, the hardware, software and infrastructure required (Evans, 2002). All these choices were set within a view about how teaching and learning were to be developed.

However as one Danish source warns (Bryderup & Kowalski, 2002) a plan is a guide to action not a substitute for it; "the existence of a written ICT plan and strategy does not guarantee the comprehensive use of ICT in schools, nor

does the absence of an ICT plan necessarily equate to the lack of ICT integration in a given school." (*ibid*.)

These authors and others (Preston *et al*., 2000) argue that a whole school approach is preferable. However this is not just a matter of having a whole school approach to ICT-related developments, but setting these within the wider pattern of changes needed. As one head put it: "It has to be a holistic thing. We haven't just worked on ICT, we've worked on many other things like giving massive support for behaviour difficulties and sorting all of those things out that were critical." (Evans, 2002)

Whole school use and development of resources

In recent years there has been a step change in the kinds of technological infrastructure and electronic resources available to schools. For instance one Australian school is reported to have provided for all staff, and students from Year 5 onwards, personal notebook computers and their own webspaces, email access and workspace. Video conferencing is available and the school has established its own intranet, placing all its resources on-line. These are accessible via radio connections from school and home. In this college the use of radio is seen as an innovation that has completely changed the nature of teaching and learning. (Richardson, 2000)

How though are such systems and resources being used in other schools, which are also implementing more student-centred approaches? A striking feature in several of the studies is the move to viewing curriculum resources as something to be jointly developed by the staff. Sometimes this was a response to perceived need which, in the case of one secondary school in Israel, this move helped to meet (Richardson, 2000).

Here many teachers saw integrating ICT into the classroom as a way to better teaching methods and lessons that would be more relevant to their pupils. This awareness appeared when they saw the potential of on-line lessons and the possibility of creating shared, net-based teaching materials. A large amount of such material has been developed and is available to pupils on-line, for home or classroom use. Online preparation for examinations is possible, and before their final examinations pupils can take part in a revision "marathon". This uses e-learning, satellite and video conferencing which allows pupils to present their questions, which are answered on-line.

In other cases a new resource may be introduced first, with its full potential emerging only over time. Providing personal laptops for teachers (Cunningham *et al*., 2003) illustrates how a single innovation can produce a variety of changes. The evaluators reported that:
- having a laptop provided access to a greater range of resources
- most respondents were using a wider range of sources to prepare lessons
- laptops were being used to facilitate the teaching of specific skills to pupils

- respondents widely reported that since receiving their laptops they had become more confident and competent in their ICT use
- teachers who were previously reluctant and inexperienced teacher users of ICT had become more confident and competent with ICT as a whole
- laptops were a means through which teachers became familiar with new software packages before using them in the classroom
- many teachers had become more motivated to use ICT in their teaching
- for many teachers the initiative had provided an impetus to develop their ICT knowledge and skills
- teachers felt they were gaining maximum impact from their laptops when used in conjunction with peripherals, such as interactive whiteboards.

How some of these possibilities have been linked together in practice is illustrated in another UK report (Evans, 2002). Evans observed that teachers downloaded lesson resources from the web or otherwise provided and stored until needed, and that this allowed teachers to share good lessons within their departments, by putting their work on a shared area. She notes that this could be extended to groups of schools, to give a great reduction in the teacher's workload.

However a move to whole school access to shared resources creates a need for training in their production and classroom use. In one Australian school (Richardson, 2000) all teachers were required to attend professional development sessions relevant to their learning area, ICT, and whole-school issues. These requirements were part of a salary award, while as an additional incentive staff received full external certification. Teachers were expected to use the skills learned in creating online content, assessing students' work and collaborating with students, parents and colleagues.

It might be assumed that, as teachers become more skilled in using ICT in student-centred ways, they would become more satisfied with what was provided by way of resources and systems. Interestingly an American study (Becker, 1994) suggests that exemplary computer users reported more problems, rather than less, a finding partly supported by others (Guha, 2003). These included not having enough space to locate computers, finding the computers limited, outdated or incompatible with other equipment and hard to keep in working order. As Becker notes; "Exemplary teachers simply had higher standards and greater perceived needs than did the other computer users" (Becker, 1994).

This emphasises a general point about providing technology resources and systems; as more teachers begin to explore its possibilities so the demands made upon it both increase and evolve. Appropriate resourcing and flexible, forward-looking planning, linked closely to what teachers actually want and need at any given stage, will be essential.

Knowledge sharing and training

Broadly speaking the approaches to school-based professional development described in the texts fall along a spectrum from informal mutual support to the use of formal training courses. Most of the latter feature in section C (on external sources of support), as formal provision typically originates outside the school, but there were also one or two cases where schools organised these for themselves.

The informal approach starts from the premiss that, in those schools where there is already some degree of mutual confidence between staff, informal knowledge sharing is a possibility. In a case study of six such schools (Dexter *et al.*, 2002) it was found that the teachers mostly viewed technology as an area of constant change, where no one was better in all areas, and so where they were 'all in it together'. This reduced anxieties about revealing weaknesses or lack of skill. The consequence was a willingness to learn from, and support, each other.

In another project-related study (McDermott & Murray, 2000) informal mutual mentoring exemplified the same general stance. The authors argue that the key to the successful mentoring they reported was time and trust. Both teachers felt comfortable asking questions of each other, no matter how simplistic these seemed, and as they became more skilled they discovered more ways of integrating technology into the curriculum. At the same time their open-minded approach made it possible to accept researchers' suggestions about giving students more choice and freedom, and time to problem-solve independently.

The next point along the informal/formal spectrum is the explicit provision of support on demand. Again Dexter and her colleagues saw this element present (Dexter *et al.*, 2002). In one case the focus was explicitly upon developing and sharing knowledge rather than upon purely collecting advice to take back to the teacher's own classroom for private use there. This "deprivatising" of classroom practice was an explicit goal in the school. Responsibility for this was shared between a technology coordinator and an instructional coach. They had reached a situation in the school where older teachers were asking to observe each other. Some progress had also been made upon getting teachers to agree to regularly examine student work together. The next point along the informal/formal spectrum is to provide regular, (rather than on-demand) one to one mentoring. This too had been introduced in the same school.

By contrast in another project-related study (Cadiero-Kaplan, 1999) a formal training course approach was tried, but most teachers were frustrated by the large amount of information provided and the limited time available to take it in. However, expanding consistent ICT use throughout the school remained a priority, given that 20% of the teachers remained resistant to change. So the school's pedagogical service centre was staffed with teachers with considerable ICT experience and identified as the school's ICT hub to

dispense pedagogical and technical advice to both teachers and students.

Finally there is another aspect to ICT use and training, where the ICT is the means of training but does not form part of the content. One community college for example (Evans, 2002) provided video conferencing in their staff development suite so that remote lessons (not necessarily involving ICT use) could be recorded and watched in real time. This was used by student teachers, but could also be used as a staff development tool for experienced teachers.

These different approaches can be integrated to meet the combination of different needs in a particular school. For instance, Richardson (2000) reports on how one primary school in Israel did this:

The school had a working group to ensure the progress of ICT integration which ran five staff meetings a year, where they addressed issues relevant to school needs. In addition two pedagogical advisors worked with and trained teachers in the pedagogic integration of computers in the learning process. Personal development decisions were taken by the principal, but all teachers participated in after school training courses. The ICT integration coordinator provided individual staff support as required, while subject coordinators took courses outside the school which integrated ICT into the subject matter. All teachers had computers and internet access at home, and received inter-staff information via email.

Taken as a set, what the approaches outlined show is a spread from informal to formal approaches, and also ones in which the focus may be on whole staff, group or individual development activities. The question here, as the last extract illustrates, may be less which specific approach is best, but which combination of methods are needed to suit the level of progress staff individually and as a whole have already reached.

Roles of technical support staff

The title of this section is perhaps more clear-cut than the content. In this area two interlocking issues emerged from the studies; what technical support staff should do, and who should do technical support.

Whoever takes on technical support it is clear that for teachers and students to get a reliable and accessible service, cooperation between all parties concerned is required. One article that covers this issue relates to a university context but has some relevance to school contexts (Butler & Sellbom, 2002). The report's authors make these recommendations:
- Schools should work to convince technology staff that reliability is very important, especially concerning technology in classrooms
- Encourage the purchase of highly reliable technologies
- Improve systems for checking and maintaining classroom technologies
- Create new approaches (including staff training) to assure that extremely rapid responses are made to breakdowns
- New classroom technology setups should be tested by faculty before

they are installed
- Classrooms should be as similar as possible
- Differences in the technologies in each classroom should be well documented
- Help faculty learn by encouraging faculty discussions about teaching, learning and technology
- Identity faculty who have used and evaluated the impact of technologies on learning and organize a workshop, conference, or set of papers to make this information more widely available to faculty
- Encourage faculty to assess and evaluate the impact of technologies on learning
- Identify attitudes and behaviors that are seen as poor or inadequate support and work with technology staff to reduce these
- A rapid response system must be in place that can deal with a wide range of problems.

Who then should provide technical support? Evans (2002) reports that one school's answer was to farm it out; they used a fully managed service to support the technology and found it to be very effective. A variant on this was used in another school, which had a repair service centre on site. Having technical staff available also allowed them to provide assistance to students in using software applications, when they were not engaged in servicing the technology. (*ibid*.)

However Evans also reports that for other schools the approach has been more eclectic, involving either incorporating technical support in other roles or extending the roles of technical support staff into some educational aspects of the school's work. A number of examples of this are noted, employing, for instance, music technology specialists to support the classroom teacher, or training learning-support assistants to work with pupils and their computers.

In other cases Evans found a strong feeling that technical experts should be employed to do things that teachers might struggle to do. Examples included a school employing a software team to write course materials for the intranet. On the other hand, in another school sixth form students planning to take a gap year between school and university were encouraged to provide technical support in local primary schools. (*ibid*.)
Whatever distribution of roles is used there is clearly a need for coordination. Evans (*ibid*.) reports one way of dealing with this was for the technical staff to be overseen by the leader of ICT development, who, as a member of the leadership team, then links the educational and technical side. In addition there was a systems manager and assistant systems manager. This group of people organised the maintenance, purchasing and development of ICT resources in the school, with two further technicians completing the team.

Section C: What local and national enabling strategies support successful use of ICT?

In this section we turn to the examples in the literature that demonstrate ways in which schools can draw upon outside support to improve their use of ICT.

We have already seen from the previous section that the degree of formality of provision is an important factor in affecting how teachers respond. There is also evidence that, compared to earlier adopters, later adopters prefer sources of advice near to them rather than at a distance (Rogers, 1995). So the dimension of distance too needs to be considered. This section therefore looks in turn at assisting innovation through:

- informal links between a school and its community and co-operation between groups of local schools
- more formal kinds of local provision, especially training courses
- agencies providing formal kinds of support but from a distance
- informal national networks that provide professional support to their members

The section concludes with an example of the ways in which elements from different levels and with different degrees of formality have been integrated into a regional change strategy.

Informal strategies at the local level

One way in which schools have made the move to student-centred use of ICT is through links with the wider community. The authors of a Greek study (Demetriadis *et al*., 2003) argue that such links enable the development of a more authentic and contextualised approach to learning supported by ICT tools. To change the human dynamics of the school does however require a rearrangement of human responsibilities, roles and priorities within the community Thus assessment methodologies, for example, should be redesigned to allow all interested community members to play an appropriate role and to disengage learning from assessment procedures based only upon the school context.

One Canadian evaluation (Granger *et al*., 2002) concluded that successful implementation required not only computers but commitment and community, with the last two being closely interlinked. In the four schools Granger and her colleagues researched they found that the schools worked continually with questions of equity, privilege, language, and community support. Each aimed to develop a philosophy of pedagogy informed by the unique characteristics of their specific communities.

One UK example illustrates what this stance might involve in practice. Kington *et al*. (2002) show how a school used the introduction of laptops to build up a 'connected learning community' in an area of considerable social and economic deprivation. Kington and her colleagues identify the main elements of the model developed by the school as:

- the creation of an 'open access' school where dialogue about learning between parents and teachers and children was encouraged
- the provision of laptops at school and home: for pedagogical and personal purposes; to develop pupils' ICT skill and competence; and to support the adoption of new teaching approaches which motivate pupils and parents and which give pupils a sense of success

- the arranging of e-Mentors in industry for pupils with little family history of formal employment
- access to skill development in ICT for parents through adult education courses on site
- a network of support for pupils and parents learning about ICT together
- the provision of a crèche to support parental access to learning
- the celebration of the learning of adults and children through assemblies.

A route taken by other schools has been to link not to the community but to working with other local schools as a way of identifying successful practice. One early regional example mentioned was the PALM project (Mumtaz, 2000). This used an action research strategy to create and sustain teachers' motivation, thereby supporting their development of both technical and higher-level computer skills. The teachers experimented with computer use in their classrooms to research their educational potential. The strategy proved very successful, taking teachers who initially had few computer skills to a point where they became confident if not highly proficient users. Support was provided throughout by three full-time project officers. The teachers were motivated to develop their capabilities, receiving both educational and technical back up, while some financial resources were also provided.

In that case, individual teachers in a range of schools were linked and supported by a project team largely using face-to-face contact. An alternative local support strategy is to take a blended approach, in which continuing face-to-face links are supported and enhanced by electronic links amongst the same local professional community. The authors of an American selective literature review discuss this (Fabry & Higgs, 1997). They point out that providing training-on-demand through a district-wide intranet can allow access to training modules, shared lesson plans and to teacher productivity tools, such as electronic gradebooks. Used as a communication system the intranet also allows email access to colleagues, and enables the local authorities to send out information to all local teachers at the same time.

A third study (Hulme & Hulme, 2000) describes another quite different way of linking local schools. The Valley Governor's School for Science and Technology in southwestern Virginia describes itself as 'a special alternative opportunity for motivated secondary school students'. Students are selected competitively from a number of local school districts and attend the school for science, math and technology for half their school time. They study the rest of their subjects in their local school. The school emphasises curriculum integration, active research by students and the use of sophisticated hardware. Here then, instead of taking innovative ICT-based learning to the students, the students are taken to the innovative learning.

Formal strategies at the local level

A more formal, but still locally based kind of support is provided by training programmes. A number of the sources have recommendations on the organisation and content of these.

For initial training, Wild (1996) recommends students working with children very early in their course, observing supervising teachers using IT and working on tasks that use teaching strategies and resources directly applicable to the teaching situations they will face. In another article (Wild, 1995) he summarises the implications of research on student-centred learning for such training. He suggests that tutors need to use these strategies:

- Teach within a coherent structure, where there are common and identifiable themes running through the course content - e.g. integrated lesson planning; role of teacher as interventionist; value of incidental learning
- Allow time for students to interact at length with various learning environments (i.e. usually software based), providing the time for intra- and inter-psychological experiences necessary so that students may construct knowledge of a deeper sort
- Modelling of desired practice by course leader and supervising teacher(s)
- Allow a maximum of hands-on time to practise and over-learn basic (i.e. lower order) cognitive skills
- Set all learning in a social context to facilitate verbal mediation; in particular, engineer group processes
- Explicitly relate (generalise) as much as possible to other areas of student learning – for example (i) Education Studies: stages of cognitive growth; constructivist theory; (ii) Communication Studies: theories of skill acquisition in writing and reading
- Base programme content on situation-specific skills and knowledge to engage situational or near transfer of practice - i.e. focus content of programme relatively narrowly, to teach for principles and approaches

- Provide for student ownership of (i) knowledge; (ii) strategies; and, (iii) software/courseware resources
- Provide opportunity for reflection (against peers and experts), articulation - i.e. within small groups and as a part of a whole class, and verbal mediation.
- Provide tasks that are obviously real and meaningful and that can be owned by students - for example students undertaking action research or reflective practice with children; using content-free software to create courseware that is directly transferable to school situations.

In another study Selwyn (1997) identifies ways of training directed to assisting those teachers whose reluctance to use ICT is based upon an anxiety about the technical use of computers. To paraphrase, Selwyn recommends that tutors:

- confront students' preconceptions, fears and expectations about becoming a computer user
- have group discussions before introducing the computer

- challenge the users' perceptions of using IT
- present the computer as a useful tool rather than a dominating machine
- warn students that it will take time before benefits appear, and that initially they will make lots of mistakes
- focus the content of the learning toward aspects of computing that are relevant to their real life, particularly when introducing older adults to IT
- ensure that each individual formulates a set of personal objectives so they can judge their success for themselves and to help them to become internally motivated
- centre the teaching of IT around their motivations, both extrinsic and intrinsic
- foster peer support within the group to reduce the isolating effect computers seem to instil in some learners
- make sessions slow paced and relatively informal with an emphasis on enjoyment, and with tasks that are 'low stress' and reasonably simple in nature
- provide longer courses if possible, as courses running over only a couple of days will have no more than a moderate effect on learners.

Selwyn argues that it is essential that tutors are enthusiastic, patient and sympathetic to the novice's situation and needs and always give clear feedback. Ideally the tutor should be from a non-IT enthusiast background themselves. In this way they will appear less threatening, be less likely to use unfamiliar jargon and expect the users to acquire knowledge and skills too quickly. They will, it is hoped, remember what it is like to be a novice themselves.

In a Canadian study Ross *et al*. (1999) offer a more generally applicable characterisation of exemplary training, based on earlier research. Ross and his colleagues saw many of these exemplary features in the situations they reported. These included involving teachers in the design of the training, providing training differentiated by teacher expertise, and in the form of continuous professional development rather than 'up-front' sessions. Teacher volunteers delivered most of the sessions, providing both self-directed exploration of the software and direct instruction in core skills.

The content of specific courses is bound to be highly variable but another report (Preston *et al*., 2000) identifies a range of supporting activities and materials that can be provided, namely:

- information on software and hardware available
- opportunities to discuss issues with others
- lesson plans and schemes of work
- ideas and help for obtaining funding
- follow up activities, such as on-line help and handouts.

Preston and her co-authors also emphasise that, given the dynamic nature of ICT, teachers will need on-going professional support after the course has finished.

The points made so far relate to standalone training, although not only to that. An American case study (McDermott & Murray, 2000) illustrates a different approach. Here the training was an integral part of a project that also included district level support, additional classroom computers, a $500 stipend for the teachers and a programme of classroom action research.

The teachers, who met as a class bimonthly, were required to research software, websites and other technologies outside of the class. Teachers designed and implemented an engaged learning unit, and their classes also covered the use of digital cameras, e-mail, web design, and conducting effective internet searches. It was a requirement that teachers were willing to give students choices in their learning, opportunities to teach one another and the chance to use technology on a daily basis. In class, the teachers discussed and compared their own and colleagues' educational philosophies. McDermott and Murray reported that one result was that the teachers developed a firm belief that technology should be integrated into the curriculum, and then implemented this belief in their classrooms.

It is clear that ambitious local initiatives will make significant demands upon the local authorities. One study identifies some of these demands (Russell & Bradley, 1997). The authors note that these demands may include in-school meeting spaces and computer access, supply cover, subsidised fees for external certification, regular time off to attend courses, salary increments linked to qualifications, allowing teachers to borrow school computers when these are not required for student use and supporting training through distance education, particularly in rural areas.

Formal strategies originating outside the locality

We turn now from the local to the regional or national context for innovation. A variety of formal strategies for supporting innovation are represented in the literature reviewed.

A pivotal element in the integration of ICT can be participation in national ICT developmental projects and initiatives, as one Danish evaluation found (Bryderup & Kowalski, 2002). Another researcher (Sheppard, 2000) found the same in the case of the Canadian schools he studied. This was because the ICT leaders involved got much of their knowledge from the multiple formal and informal training and educational experiences provided by such initiatives. However in schools where they did not then share this knowledge implementation was limited to their classrooms only, and when they left the school implementation stalled. This gives a clear picture of the way in which teachers prepared to make links outside the local situation (a characteristic of Rogers' (1995) earlier adopters) could then potentially mediate the new knowledge to colleagues less willing to take national initiatives on trust.

Projects are likely to combine a number of approaches and purposes, but another kind of national initiative aims to help solve a particular innovation problem. In Quebec, Canada, for example one target was to assist schools with their development planning (Richardson, 2000). To do this a ministerial team and website were set up to support the schools which also had:

- access to relevant official documents published by the Education Ministry
- guidelines for the acquisition of equipment (budgetary regulations and admissible purchases)
- email contact for schools with experts in the field
- a complete guide on drawing up a school plan
- a repertory of over 100 school plan-related comments
- examples of plans for integrating ICT into teaching establishments.

A Dutch initiative was directed at a different problem. It was an important goal in Dutch national policy to motivate and train the teachers who had so far made little use of ICT in their classroom practice. One way that they planned to do this was by setting up a national electronic database to match good ICT-based practice with available training (Brunemann *et al*., 2000). At the time the article was written this was not fully implemented but it was envisaged that it would allow a teacher to search for examples of good practice by establishing her current level of competence and then select possible examples by choosing, for instance, subject and teaching methods to be used. For a chosen example the entry would then indicate the goals, the necessary technical and teaching skills the teacher would need, the technical and organisational features at school level and, finally, where the corresponding training would be obtained.

This is one open-ended way of using the technology itself to offer implementation support. Though centrally provided it potentially gives teachers a considerable degree of control over what they learn using the system. Another option is to use the technology to help deliver a centrally specified and monitored initiative, as exemplified by the approach used by many of the NoF training providers (Kirkwood, 2000).

Another strategy has been for national government to make a direct intervention at the level of individual schools or teachers to support the innovation. The provision of personal laptops (Cunningham *et al*., 2003) , which was mentioned earlier, is an example of this.

However providing support from a distance is no longer the exclusive prerogative of outside agencies. There are the beginnings of a move by individual schools themselves towards providing distance support for other schools without any direction or intervention from either national or local agencies. The sources give several instances of this.

One example is of a specialist language college which employed video-conferencing to work with partner schools in France, Germany and Spain

(Harris & Kington, 2002). The system was used to support MFL teaching and learning with students taking part in 20-minute discussion sessions with their peers on the Continent. This not only benefited the students but also no doubt provided a distinctive professional development experience for the teachers concerned.

The same report describes another case, where a technology college had developed online course materials. These were made available to other schools for an annual fee. One school that took up this offer did so partly because it was seen as a way of helping to raise the performance of students who were likely to achieve lower exam results, but also because staff felt that the difference in the method of course delivery would be an attraction for demotivated students, and extend their knowledge and skills in ICT. Students accessed the materials from the college or their homes, and then had worked at their own pace through the assignments. These activities were supervised and marked in the usual way. (*ibid*.)

Another college is reported to have used a different mix of technologies to produce teacher training materials for sale to other schools, through using classrooms with television recording equipment in which to deliver demonstration lessons (Evans, 2002). An advanced skills teacher was detailed to draw together learning materials, and to work with a commercial company to write online materials, creating a series of lessons. Schools were able to buy just this package, or add a video of an experienced teacher teaching the lessons, recorded in the school. A third option was also to add an inset commentary on the lesson, talking the viewers through the video of the lesson.

Organising production of high quality resources is not a simple task. In one source (Littlejohn *et al*., 2003) an HE institution identified a number of considerations to bear in mind when providing strategic support for lecturers who are designing and implementing ICT-based resources:

- Encouragement of subject-based teams of academics to work together
- The need to work on a need to know basis, with specific deadlines
- The need for support from mentors, especially with IT problems
- Availability of local technical support
- Implementation of clear procedures for quality assurance of online materials
- Feeling of ownership of the modules by department/college managers and academics
- Clear communication to local management of the benefits of academic staff devoting time to this area of work.

This last point is emphasised by the fact that the initiative involved sixteen academics being freed from 50% of their teaching for five months to take part in the staff development programme to become online module authors.

Informal support for innovation provided at a distance

Not all support at a distance is formal and structured in the ways just described. There are a number of electronic networks (such as Becta's ICT Research Network) devoted to professional development that link teachers to others outside their own locality. As one report notes (Preston *et al*., 2000) these networks are something that benefit experienced teachers by providing:

- dissemination of good practice
- personal development, such as increased confidence in using ICT and public speaking
- communication and collaboration with other teachers
- increased motivation to use ICT effectively
- better access to resources and research
- improved ability to write educational materials for the World Wide Web
- greater understanding of the culture of the World Wide Web
- a sense of community and collegiality.

A similar judgement appears to have been reached in the Netherlands, where the government has provided financial support for up to 200 teacher networks which include an electronic dimension. An earlier Dutch programme of this sort is reported to have provided a very effective alternative to more traditional in-service training, with the programme reaching 50% of the target schools (Brunemann *et al*., 2000).

However a strong note of caution about online communities is sounded by an Australian report. Downes *et al*. (2001) observe that:

> "It is important that all stakeholders realise that neither 'online learning communities' nor 'online professional development' can provide quick fixes for the complexities of continuing professional development. While 'learning communities' come up over and over again as a necessary condition for effective and sustained teacher development, they are not an easy solution, nor one that should stand alone as a major strategy. Rather, they should be an integral part of the sustained school-based teacher inquiry approach where their special contribution is to support and extend the local networks by offering connections and resources from outside the school or district. Similarly, online professional development does not hold any magic. There is no simple or easily affordable answer to the complex matter of designing effective systemic strategies for effective teacher education programmes…" (Downes *et al*., 2001: p3)

Once again the underlying message is that a combinations of methods is needed. One example of this is given below.

Integrated strategies

We finish with one illustration of an integrated strategy. In an analysis of the way in which ICT development has been promoted in Virginia, Hulme & Hulme (2000) report that a very significant feature was the role of higher education.

Virginia Tech pioneered the innovative use of ICT in a number of ways. With federal and other funding it worked with county school authorities to set up the Blacksburg Electronic Village. This set out to improve education for the 4-18 year olds and to build a strong community of learning linking schools, teachers, students, libraries and parents. This therefore represents on a district level something rather similar in conception to the school-community partnerships we saw earlier at the single-school level. The Tech also worked with school administrators and teachers to integrate use of web-based resources in subject teaching across the County, enabling teachers to develop the web-based authoring skills needed to produce lesson plans and learning activities. Virginia Tech's own web site was then use to disseminate good practice in the use of ICT in teaching to all its partner schools across the entire state.

Clearly there are many ways in which local and national bodies can help schools make more successful use of ICT. However as with school-based approaches it may be that success depends as much upon combining different activities within a clearly conceived overall strategy as upon the presence or absence of any specific approach. In the final section we look at some of the weaknesses in the literature set, viewed as an overall guide to policy and suggest some broad lines for future development.

Section D: Next Steps

The literature reviewed covers a great deal of ground, only part of which has been summarised here. However as an overall guide to practice and policy the literature arguably has four main weaknesses:

- Ways of enabling individual teachers and schools to make better use of ICT are largely treated as separate problems.
- The overriding importance given to using ICT to facilitate the emergence of a student-centred curriculum focuses most of the school-level research on the small proportion of schools that are finding ways of doing this successfully. This leaves under-researched the use of ICT to reinforce and enhance the existing curriculum, whether this is viewed as an important step towards assisting the emerging curriculum, or as a possible alternative final destination in its own right.
- By focussing attention upon either the individual teacher or the whole school experiences of successful schools the literature leaves under-researched the circumstances in which the innovation can succeed with groups of staff within schools.
- By focussing largely upon examples of schools already at the most complex level of development as exemplars the literature does not help in understanding how schools make the previous transitions from level to level, or what role ICT might be playing in schools that in more general terms face considerable difficulties.

These concluding observations therefore first suggest a way that the progress at whole school and individual teacher levels might be viewed together, and speculates on what that could reveal. Using that framework a number of topics for further research are then suggested. These have been selected to fill the gaps identified above.

Most of the articles reviewed focus either upon the individual teacher or upon the school as a whole as the unit of analysis. However other issues emerge about the innovation tasks facing both if they are viewed together. The study by Ertmer and her colleagues (1999) offers one useful framework for making this connection.

As we saw earlier, they identify a three-stage model of different and broadly sequential levels of individual teacher development in the use of ICT; there is also an implied fourth level, namely non-use. However we can also use their three categories to distinguish the positions of whole schools as well as individual teachers. This enables us to speculate about what the implications might be of various kinds of match and mismatch between a schools' position and that of an individual teacher within it. Figure 1 shows the pattern of these matches and mismatches.

Teacher sees ICT as facilitator for emerging curriculum	*Teacher ahead of school*	*Teacher ahead of school*	*Teacher and school in step*
Teacher sees ICT as reinforcement to existing curriculum	*Teacher ahead of school*	*Teacher and school in step*	*School ahead of teacher*
Teacher sees ICT as supplement to existing curriculum	*Teacher and school in step*	*School ahead of teacher*	*School ahead of teacher*
Non ICT-using teacher	*Teacher and school in step*	*School ahead of teacher*	*School ahead of teacher*
	School sees ICT as supplement to existing curriculum	School sees ICT as reinforcement to existing curriculum	School sees ICT as facilitator for emerging curriculum

Figure 1: Relationship between levels of development of ICT use for schools and individual teachers.

What this brings out is that what a teacher needs, and what chance there is of the school providing it, is a function of the relative positions of teacher and school in terms of progress in using ICT, not just the absolute position of either.

Consider first the positions where the teacher is behind the school. In those cases the recommendations of Ertmer and her colleagues (*ibid*.) could possibly be met from within the school itself, as the idea is basically to put teachers in productive touch with others who are already at a later level; in these situations such teachers are available within the school already. This applies across schools at every level of development.

Where a teacher is in step with the school things are rather different. Firstly if both teacher and school are at one of the lower levels of ICT development then they seem unlikely to challenge each other to change the situation greatly. In those circumstances any push for innovation will presumably need to come from outside.

However where they are both at the later curriculum-reinforcing level of use a different situation exists. If both are aiming to explore to the full the

possibilities of using ICT to reinforce or enhance delivery of an existing teacher-led curriculum then this itself could lead to a mutual interest in certain kinds of ICT-led change, such as the introduction and use of interactive whiteboards. This might be enough to promote innovation without external pressure, although Sheppard's research suggests it might not be easy to sustain.

The position is different again in schools where both teacher and school favour using ICT to promote an emerging curriculum. Many of the sources, such as Evans (2002) and Richardson (2000), show such schools as learning organisations that are continually looking for ways of improving teaching and learning. For these schools the external rate of change in available ICT systems themselves probably offers sufficient (possibly more than sufficient) amounts of external change to maintain their momentum as innovating organisations. Provided the resources for technical updating kept coming, this would continually promote internal debate about, and experimentation with, ICT. This would of course benefit individual teachers as well as the school as a whole.

The situation of teachers who are ahead of their schools is unlike all the cases identified so far. They by definition are likely to have difficulty realising their professional ambitions for ICT use, and to lack at least some of the kinds of internal support and resources that they would need to do this. Successful professional development for these teachers would involve using external sources of support for ideas and confirmation of the value of what they are doing. In addition they would need a sufficiently supportive immediate environment within the school to implement such ideas, at least in their own practice. In secondary schools, for example, particular departments might provide such a context, even if within the staff generally there was less active support for ICT-based innovation.

The literature reviewed for this report has the merit of both answering many questions and raising many more. The analysis given above suggests at least five issues that arguably need further investigation:

1. What are the likely indicators that a school is near to making the move from one level of ICT integration to the next? For schools that are at such a transition point what are the key factors that affect whether or not they make the transition successfully?

2. Where only a small minority of staff are innovating with ICT what kinds of support are needed to ensure that they continue to do this? What is needed to enable the innovation to "break out" of this small group and be taken up more widely within the school?

3. What examples are there of highly innovative schools successfully using ICT mainly to reinforce their existing teaching and learning practices rather than to change them? How did they reach this

position? In what ways do they maintain their innovativeness and what can other innovative schools learn from their experiences?

4. What positive roles (if any) have ICT-based innovations played within successful strategies for turning round failing schools?

5. In what ways are highly innovative schools co-operating on ICT-based innovation with others that are less far forward in their use of ICT? What difficulties do such partnerships encounter and how are they being overcome?

Some of the information needed to answer these questions no doubt already exists, while for some of them more research is probably needed. However if we had answers to all of these questions we would have a much fuller picture of how ICT-based innovation is to be enabled more successfully in most schools and by most teachers.

Appendix A: Parameters of the literature search

A range of sources of literature and journal indexes were used in the searches, and these are listed below:

- Becta's Evidence Database – Becta's collection of key ICT research literature
- Educational Resource Information Centre (ERIC) http://www.eric.ed.gov/
- British Education Index - www.bei.ac.uk/
- Australian Education Index
- Swetswise – www.swetswise.com
- British Library Public Catalogue - http://blpc.bl.uk/
- Bath Information and Data Services (BIDS) http://www.bids.ac.uk/
- Regard – www.regard.ac.uk

These sources were checked for publications between 1993 and 2003. This gave us access to a large number of educational research journals and individual research papers. Each of the sources was searched using the following search terms, in order to identify the research evidence concerning the enablers to teachers' use of ICT:

ICT enablers
Teacher ICT use
Teacher computer use
Teacher technology use
School ICT use
School computer use
School technology use
Using ICT
Using computers
Using technology
Integrating ICT
Integrating computers
Integrating technology
Increasing ICT
Increasing computers
Increasing technology
Teacher computer acceptance
Teacher ICT acceptance
Teacher technology acceptance
ICT professional development
ICT skills development
Computer anxiety
Technology resistance

Appendix B: The Becta ICT Enablers Survey

The survey data was collected through the use of a brief questionnaire, completed by visitors to Becta's research website. This is therefore only an opportunistic survey; the respondents who took part do not necessarily represent exactly the views of the teaching population as a whole, although the survey does give a general picture of the views of teachers regarding the enablers to ICT use.

In total, 103 visitors to the site responded to the questionnaire, many of them suggesting more than one enabler, so the total number of individual suggestions was 456. The responses to the questionnaire are summarised in the tables and graphs below:

Table 1: Teacher level enabling factors

Enabling Factor	Number of responses	Percentage of total responses
High quality resources available	51	21.3
High level of technical support	37	15.5
Full access to software & hardware at all times	35	14.6
Access to own personal laptop	34	14.2
Good quality training available	34	14.2
Access to an interactive whiteboard	24	10.0
Others	24	10.0

Graph 1: Teacher level enabling factors
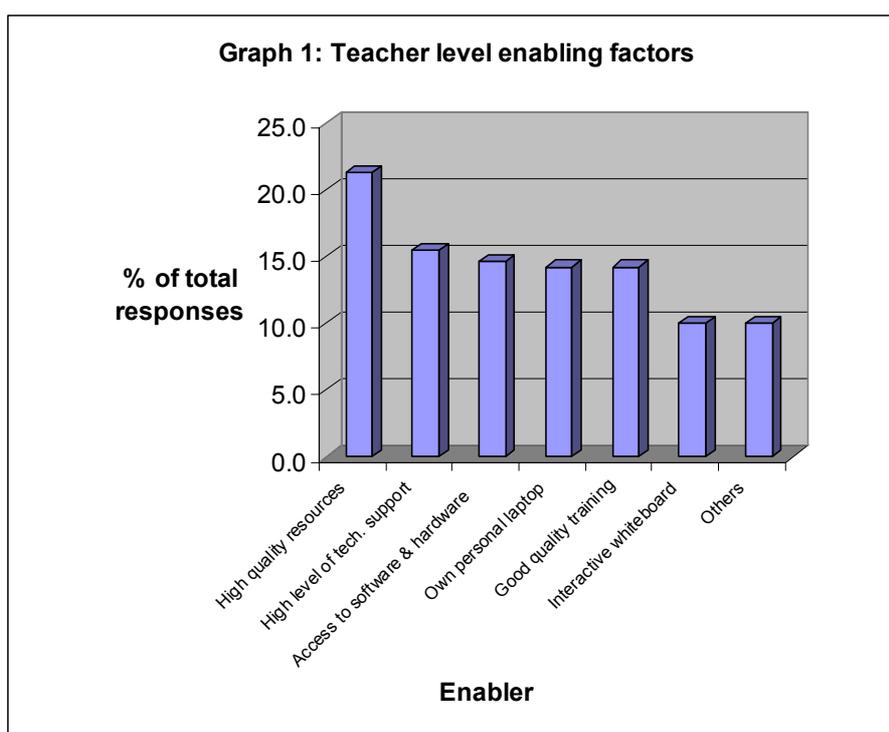
Table 2: Whole school level enabling factors

Enabling Factor	Number of responses	Percentage of total responses
Programme of staff ICT training / CPD in place	42	19.4
Effective timetabling of rooms & equipment / access to resources	33	15.2
On site technical support	32	14.7
Support / ICT vision from senior management	31	14.3
Whole school policies on using ICT across curriculum	31	14.3
Others	26	12.0
Provision of interactive whiteboards in all classrooms	22	10.1

Graph 2: Whole school level enabling factors
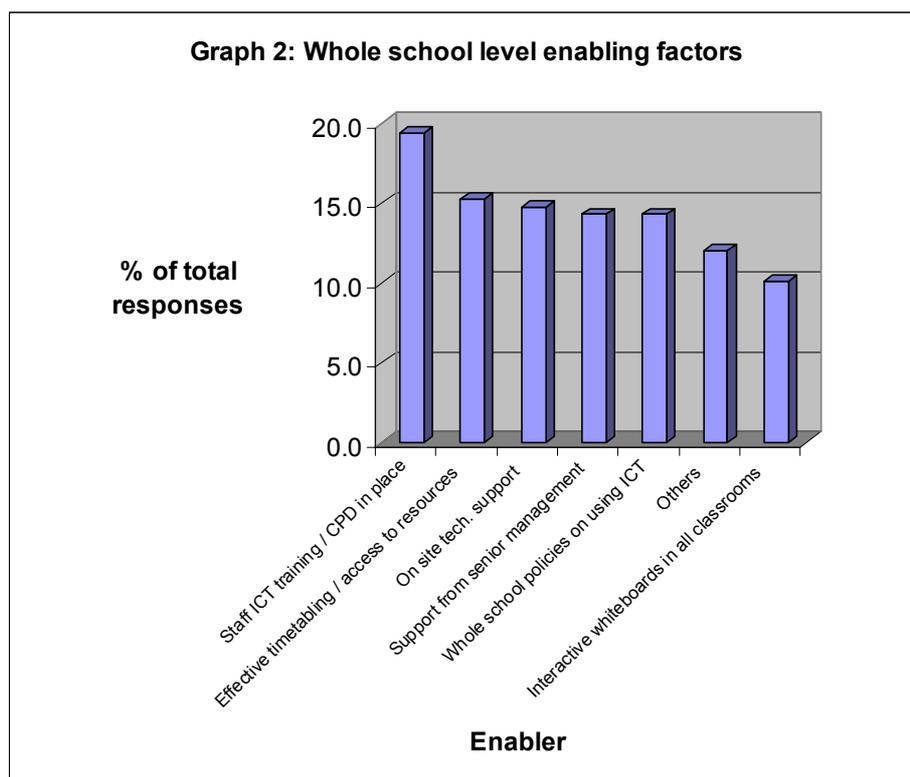
The precise form of the questions posed to the participants is given in the sample questionnaire below.

Becta ICT Enablers Survey – questionnaire

'What factors enable the use of ICT?'

Following our recent research into the barriers to the use of ICT in education, we are now gathering evidence of the factors available to teachers and schools which help them to break through these barriers, and enable them to make successful, widespread and integrated use of ICT in their work.

Please help us by recording your ideas below.

Individual teacher enablers
In particular, which of the following factors are most successful in encouraging you, or your colleagues, as individual teachers to regularly integrate the use of ICT into day to day teaching?

☐ Access to own personal laptop

☐ High quality resources available

☐ Full access to software and hardware at all times

☐ High level of technical support

☐ Access to an interactive whiteboard

☐ Good quality training available

Other (please state)

[text box]

Whole school enablers
Which of the following whole-school policies and practices are, or would be, most effective in ensuring the widespread use and integration of ICT throughout your school?

☐ On site technical support

☐ Programme of staff ICT training / CPD in place

☐ Support / ICT vision from senior management

☐ Whole school policies on using ICT across curriculum

☐ Provision of interactive whiteboards in all classrooms

☐ Effective timetabling of rooms and equipment / access to resources

Other (please state)

[text box]

Your details

To help us categorise and further analyse the results of this survey, please provide us with the following information:

Job title:

Primary/Secondary:

Subject responsibilities:

Email:

(Email address not essential, but we may wish to contact you to discuss your comments further)

Submit

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