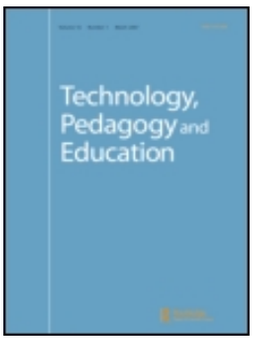

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Computer Innovation in Schools: a review of selected research literature

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Introduction

The development of information technology (IT) use in education can be seen as part of the broader field of educational change. According to Cox & Rhodes (1989): "It has been recognised that many of the barriers to ... the adoption of microcomputers [in schools] are specific examples of the barriers to ... change in general". This suggests that a broad approach to the study of issues involved in using computers in schools is warranted. Such an approach would consider the use of computers as a specific case of school innovation in general, and therefore benefit from the considerable corpus of research existing in that area. This could also be beneficial in helping researchers avoid the not uncommon external pressures (perhaps from politicians, parents, governors or computer companies) to focus on technological factors of high visibility, e.g. the number and type of machines. A broader approach might also generate more positive attitudes amongst those involved in change, since it draws upon literature, case studies and terminology which may be more familiar.

This literature review is presented in chronological order and concentrates first on general factors affecting innovation in educational organisations. It then proceeds to review studies specifically concerned with computer uptake by teachers. A concluding section briefly summarises the review, identifying in particular its relevance to in-service teacher education and the professional development of all those concerned with innovation and the management of change in schools.

Factors Affecting the Implementation of Educational Innovations

Selected Studies from the 1970s

Since the 1970s there has been a growing interest in the implementation of innovations in schools (Berman, 1981). The impetus for this interest was research that showed that many change efforts failed to have an impact on classroom practice (Gross et al, 1971; Charters & Pellegrin, 1973).

"Implementation", according to Fullan (1985), is "the process of altering existing practice in order to achieve more effectively certain desired learning outcomes". One of the major early contributions to the study of the implementation of innovations in schools was published by Gross et al in 1971. They conducted a case study of the introduction of an educational innovation in an elementary school (Cambire Elementary) with the objective of "increasing our knowledge of conditions ... that may serve to block or facilitate the implementation of organisational innovations" (p. 42). The authors distinguished three major stages in the innovation process: initiation, attempted implementation and incorporation.

Their study contended that most of the research on organisational innovations to that date "had been based on a truncated version of the process [of innovation]" (p. 42) and described the existing theories as placing "primary emphasis on the ability of a change agent to overcome the initial resistance of organisational members" (p. 1). They argued that those formulations disregarded other major issues: (a) organisational members who are not resisting change may encounter obstacles preventing implementation, (b) many of these obstacles can only be removed by the organisation leaders, who may not even be aware of them, and (c) organisational members who did not resist the innovation at the beginning may change their attitudes and start opposing change efforts in a later stage as a result of the presence of unsolved problems.

Gross et al found that the majority of the teachers at Cambire Elementary had failed to implement the innovation six months after its announcement. They attributed this outcome to the presence of five barriers: (1) the teachers' lack of clarity about the innovation, (2) their lack of the skills needed for implementation, (3) the unavailability of required instructional materials, (4) the incompatibility of organisational arrangements and (5) lack of staff motivation. The authors concluded that the school principal's strategy for change was inadequate for two main reasons: (1) it was based on the assumption that teachers would be able to 'figure out' the procedures given the goals and therefore failed to create the mechanisms to cope with the anticipated needs, and (2) it did not create information systems to identify unexpected problems.

Doyle & Ponder (1977) propose an analytical framework for studying teacher adoption of innovations. They argue that "if an effective change strategy is ever to be devised, it must be constructed on a more thorough understanding of the naturally existing mechanisms which operate in school environments". They point to the high functional autonomy and relative isolation in which most teachers work and state that most educational innovations tend to disrupt this autonomy. Doyle & Ponder classify teachers as 'rational adopters' (who should be convinced by rational arguments), 'stone age' obstructionists (who change strategies, try to neutralise) and 'pragmatic sceptics' (who adapt rather than adopt innovations).

The authors argue that the perceived 'practicality' of a change is the crucial determinant in a teacher's decision to adopt and implement the innovation. According to Doyle & Ponder the 'practicality ethic' is a critical link in the knowledge-utilisation chain in schools. Their definition of 'practicality' is based on 'instrumentality' (the innovation is realistic and clear and guidance is available), 'congruence' with existing practices, classroom conditions and the teacher's self-image, and costs, defined as the ratio of investment to return for the teacher.

The 1980s

Brown & McIntyre (1982) studied the main factors that influenced the way science curriculum innovations were implemented in Scotland. In accordance with Gross et al (1971), Brown & McIntyre found that the issue of clarity of the innovation was crucial to secure teacher implementation. They say: "... if the concept has not been clarified, the teachers may simply ignore it and make no attempt to implement the new ideas" (p. 117). They attributed the lack of clarity (again in accordance with Gross et al's findings) to an assumption made by the initiators of the innovation. They assumed that "professionally competent teachers, given the general ideas, would be able to develop appropriate procedures for themselves" (p. 129).

Brown & McIntyre argue that innovations must make sense in terms of teachers' concerns. Teachers do not regard the definition of educational aims and principles as part of their job. They are primarily concerned with issues such as time, resources and classroom management. The authors put forward the view that:

> ... it is entirely rational for teachers ... to give priority to ensuring that they can cope fluently with the practical situations with which they are faced and meet the criteria for which they are accountable (coverage of the syllabus, maintenance of control, pupil safety).
> (p. 123)

They conclude that "unless the innovative ideas can be translated into these terms, consideration of such ideas remain (for the teacher) ... an empty and irrelevant exercise" and that support in the form of curriculum documents,

instructional materials and training must also be designed and delivered in a way that is responsive to the teachers' concerns (p. 123). They suggest that the provision of support has to take account of issues such as the value of classroom autonomy in teachers' professional status and state that more research is needed to determine the types of support teachers would welcome as not conflicting with their autonomy.

Nicholls (1983) found that early innovators were key factors in the successful implementation of innovations. Innovators play an important role in the process of change since their adoption of an innovation causes other teachers to become aware of it and if it proves successful, early scepticism may turn into a recognition of its utility.

Huberman & Miles (1984) carried out a large scale, multi-site ethnographic study of twelve major innovations in schools in the USA. They conceptualised the innovation process in a dynamic model. In their model, outcomes are influenced by internal school variables (demographics, prior innovation record, organisational rules and practices and user purposes and assumptions) and external variables (nature and level of assistance and characteristics of the innovation). Outcomes specified are: stabilisation of use (the degree of 'settledness' of the new practice in the users' instructional repertoires), percentage of use (the number of users in proportion to the number of eligible users), institutionalisation (the degree to which the innovation is 'built in' to the ordinary structures and procedures of the school), student impact, user capacity change (changes in users' knowledge and skills beyond the immediate requirements of the innovation) and job mobility.

The authors present a great number of conclusions in the form of causal networks, of which only some, of particular relevance to this review, are presented here.

Nearly half of the teachers adopted the innovation because of administrative pressure. The rest often invoked motives of professional growth such as establishing contact with specialists or learning new skills that could help them in general in their teaching. In brief, there was less user interest in innovation-specific benefits than in second order rewards (p. 272). Adoption, the authors note, "(rarely) resulted from a perceived problem to which the innovation was seen as a solution" (p. 272).

Another important factor was the quality and quantity of assistance available to the teachers. The authors are categorical in saying:

> Large-scale ... innovations lived or died by the amount or quality of assistance that their users received once the change process was underway ... administrative pressure by itself ... got nowhere. (p. 273)

Referring to the innovations that failed, the authors found as a common pattern the absence of "a local advocate sufficiently committed " (p. 269) and a low level of user commitment. User commitment, the authors argue, "gets

built through practice mastery leading to practice change, through assistance and a strong administrative presence" (p. 269).

Fullan (1982a, 1982b, 1985) has become one of the most widely quoted authors in the field of planned educational change. He sees three broad phases to the change process: adoption, implementation and institutionalisation (1982a, p. 39). In his extensive review of related research, Fullan found that not always, not even usually, are educational changes adopted because they meet a given need better than existing practices (1982a, p. 41). Schools, in his view, favour the adoption of innovations that are bureaucratically safe (add resources without requiring behavioural change), ease external pressure and lead to the approval of peers. In other words, schools tend voluntarily to adopt innovations which promote their image as up-to-date and efficient. It is relatively easy for schools to adopt complex innovations. Complications arise when they try to implement them (1982a, p. 50). Fullan cites the findings of a survey carried out by Nelson & Sieber (1976) in 679 urban schools in the USA who found that the publicity value of innovations and faddism were major reasons for adoption.

The complexity of implementation, says Fullan, is due to its multi-dimensionality. He identifies three major dimensions of change: teaching materials, teaching strategies and teaching beliefs, and warns that implementation must occur in all dimensions for the desired outcomes to be achieved. According to Fullan:

> Implementation involves the development of new teaching approaches and examination of underlying beliefs ... most (change) efforts ... have concentrated on 'paper' changes ... (overlooking) people (behaviour, beliefs, skills) in favour of things (regulations, materials) and this is essentially why it fails more times than not ... people are much more difficult to deal with than things (but) also much more necessary for success. (1982b, p. 249)

Speaking on the reluctance of teachers to implement many innovations, Fullan says:

> Teachers' reasons to reject many innovations are often every bit as rational as those of the advocates ... innovations are frequently 'rationally' advocated from the point of view of what is rational to the promoter, not the teachers. Sometimes innovations ... turn out not to be translatable into practice with the resources at the disposal of the teachers ... or assume conditions different from those faced by teachers. Other proposals are not clear about the procedural content. Others fail to acknowledge the personal costs it will take (for the teachers) to develop the new practices ... Implementation will occur to the extent that each and every teacher has the opportunity to work out the meaning of the implementation in practice. (1982b, p. 257)

He concludes teachers should not be expected to implement an innovation unneeded, unclear or unrealistic in time, resource or support.

Fullan proposed a list of twelve factors as critical for implementation:

Characteristics of the Innovation
1 Need for change
2 Clarity, complexity of the change
3 The quality of the change
Characteristics at the Local Education Authority Level
4 History of innovation attempts
5 Expectations and training for principals
6 Teacher input and technical assistance for teachers
7 Board and community support
8 Time line and monitoring
9 Overload
Characteristics at the School Level
10 The principal's actions
11 Teacher-teacher relations and actions
Factors External to the School System
12 Role of the Government Educational Authorities

Table I. Factors affecting implementation (Fullan, 1985).

Factors 1, 2 and 3 have been discussed above (Gross et al, 1971; Charters & Pellegrin, 1973; Nicholls, 1979). Fullan warns against 'false clarity' where an innovation is interpreted in an oversimplified way. For example, an approved textbook may come to embody the innovation itself, failing to incorporate some of its significant features. Another problem is 'superficial clarity'. In this situation an innovation may be dismissed on the grounds that 'we are already doing that' but again looking only at part of the innovation (usually materials) and ignoring changes in strategies and beliefs. Clarity, with all its bearing on implementation, is down-played by the author as an important factor in the adoption phase. As he puts it: "many educational changes have been adopted without any clear notion as to their specific meaning" (Fullan, 1982a, p. 43).

The history of previous attempts (factor 4) to innovate was shown first by Sarason (1971) to be of importance and relatively independent from the innovation because it is based on people's experience.

Factors 5 to 9 in Table I refer to the issues of support given to principals, teacher feedback, support and training given to teachers, parent support, monitoring systems and how teachers cope with an increase in

their workload caused by the innovation. In terms of teacher training and support Sarason argues that "... it is not the amount of in-service training but the nature of it that counts" and recommends "a task-focused continuous professional development combining a variety of learning formats and a variety of trainers" (Sarason, 1971, p. 76).

Fullan contends that, at the school level (factors 10 and 11), an active role of the principal has been shown as essential in "virtually every line of inquiry" (1985, p. 76) in influencing the extent of implementation. He argues that teachers' colleagues are a preferred source of knowledge and skill and therefore the lack of time to interact with each other is a prime obstacle to implementation.

Computer Uptake by Teachers

Research on the use of computers in schools has boomed in the last two decades. This review now moves on to identify and summarise the findings of a number of important studies concerned with computer innovation in schools internationally. Although the main focus is on computer uptake by teachers in secondary schools, relevant studies carried out in primary schools are also considered since preliminary evidence seems to suggest (Fullan, 1985) that issues at each level are often closely related and perhaps one has something to learn from the other.

Early Studies

Anderson et al (1979) carried out one of the earliest investigations of computer uptake by teachers. It was designed to assess both technological and sociocultural factors influencing computer use. The investigation was based on a postal survey of more than 3500 secondary teachers in the USA. Anderson et al refer to two competing theories as relevant for explaining adoption decisions made by teachers. One theory is that of technological determinism (Ellul, 1964). In this theory, the implicit assumption is that "as long as the facilities are available and teachers are trained in computing, adoption ... is inevitable" (p. 229). The other is the theory of cultural and social determinism (Parsons, 1966). The sociocultural approach, according to Anderson et al, does not deny the importance of technological factors such as level of resource availability, but suggests that factors such as attitudes and roles must be taken into account. They point out that most sociologists of change take an eclectic position postulating that the decision to adopt a new technology is a function of values and norms as well as social structures, such as organisational characteristics, communication struct- ures and occupational features (Rogers & Shoemaker, 1971).

In assessing the sociocultural factors they divide what they consider to be the potential determinants into three categories: attributes of teachers

(attitude towards computers, level of training, teaching experience, subject, gender), features of the work setting (grade level taught, range of levels taught, size of the school, resource availability) and community characteristics (size of the population, distance from large urban areas).

Anderson et al found a large number of 'drop outs', i.e. teachers who had discontinued computer use. The most highly significant predictors of computer use were: (a) resource availability, (b) attitude towards instructional computing, (c) training, (d) confidence and (e) teaching experience. They admit, however, that regression analysis does not indicate whether adoption is affecting attitude or vice versa. They did not find any effect of gender on computer use. Men showed a more positive attitude to computers than women but not a higher rate of computer use. The authors concluded on the basis of their results:

> The extreme positions of technological determinism and sociocultural determinism are inadequate. While numerous social factors were found to operate in the process of teacher acceptance of instructional technology, slightly over half of the explained variance in adoption is accounted for by technological factors (amount and availability of computer resources). (p. 247)

The sociocultural issues underlying the process of computer use in schools are also discussed by Blumenfeld et al (1979). They argue that "patterns of beliefs and behaviour that make up cultural systems can act as barriers to technological change" (p. 187). Conventional teaching methods, they say, provide independence, self-sufficiency and autonomy for the teacher and patterns of behaviour that have paid off in the past will be maintained until expectations of better pay-offs have been envisioned. To study computer use by teachers they use a model proposed by Niehoff (1966). In Niehoff's model, two forces act on the process of innovation, i.e. the actions of the innovator and the reactions of the recipients. The characteristics of the first comprise: (a) the methods of communication used, (b) the type of participation obtained from the recipients, and (c) how the innovation is adapted to existing cultural patterns. Characteristics of the recipient include: (a) the need the recipients have for the innovation, (b) the practical benefits the recipients perceive from the innovation, and (c) the participation of the recipients' traditional leaders in the innovation process.

Blumenfeld et al argue that participation of the recipients in the planning of the innovation is critical in determining take-up by the recipients. This seems to contradict evidence found by Fullan (1982a, 1985). In addition, Blumenfeld et al point to the issue of centralisation of computers in a separate room as a barrier to innovation since "sending the student off to some other part of the building is perceived (by the teacher) as losing control of the student and his instruction" (p. 189). The fact is that classroom-based instruction is an established pattern that cannot be expected to be modified in the short term. They state, however, that

"utilisation of traditional practices should not be viewed as an undesirable compromise ... after the computer (is used) by adapting established practices, more effective and original utilisation can be attempted" (p. 189). In discussing the cost-reward structure of using computers the authors argue that "the perceived benefits (of using computers for teaching) must be weighed against the risk of disrupting survival techniques" (p. 191).

Finally, Blumenfeld et al emphasise the role of local leadership in innovation implementation, a finding supported by a number of other authors (see Fullan 1982a, 1985, and Huberman & Miles, 1984).

Studies in the Early and Mid-1980s

An influential research agenda was proposed in 1983 by Sheingold et al (1983) on the basis of a large-scale investigation of three US school districts. Their study considered four levels or contexts within which an educational innovation takes place: community, school system, individual school and classroom. A case-study methodology was employed. They proposed six main issues as an agenda for future research: (1) access to computers, (2) new roles in response to computers, (3) integration of computers into classrooms and curricula, (4) quantity and quality of software, (5) preparation of teachers for using computers, and (6) effects and outcomes of the instructional use of computers. One of their main findings, confirmed in several studies in the following years (see Bliss et al, 1986; Chandra et al, 1988; Somekh, 1989; Plomp et al, 1990, among others) was that:

> ... teachers felt inadequately prepared to use computers in their classrooms. They felt this despite the fact that in both sites there were in-service courses, opportunities for study in nearby colleges and universities, and helpful teachers or computer advisors ... Most teachers did not seem to want more or different courses. What they wanted most was more time to use the machines, to develop their expertise, and to review available software and plan for its use in the classroom. (p. 429)

Referring to the crucial issue of teacher time investment, Sheingold et al suggest - even though they fail to include it as another point of their research agenda - that it is important to examine the cost-reward structure for such an investment. They add that "in the absence of institutional incentives ... the intrinsic factors which account for teachers' interest and commitment deserve attention" (p. 430).

Cuban (1986) carried out a study of teacher use of machines since 1920 that gives a broader technological and historical perspective on the problems associated with the use of machines in teaching. His aim was to determine "to what degree did teachers use a series of technologies ... aimed at making teaching and learning more productive" (p. 217). In criticising part of the literature on computer uses in education, he points out that no

study of teacher use of technology can be carried out without an acute sensitivity to the conditions under which teachers work in schools.

Cuban reached two main conclusions: firstly, that technologies went through a cycle that he describes as "exhilaration - scientific credibility - disappointment - blame (the teachers for blocking the advance of the technology and classroom improvement)". Secondly, that teacher use of these technologies seldom exceeded a fraction of the school week on the part of even the most committed users. He estimates that teacher use of computers "will be tailored to fit the teacher's perspective and the tight contours of schools and classroom settings" (p. 218). He adds:

> Within the ways the schools are currently structured (the graded school, self containing classroom, a segmented curriculum ...) teachers teach the way they do simply to survive the impossibilities inherent in the workplace. The choices teachers face are to continue to do the best they can with what they have, or to risk what seemingly works but trying to meet ... expectations that are out of sync with organisational realities ... It is not (lack of) funds that spells success or failure for (educational innovations) it is the high personal costs that teachers have to pay when they try to implement different ways of teaching within current organisational structures and beliefs. (p. 221)

Bliss, Chandra & Cox published findings based on an in-depth case study of the implementation of computers in a UK secondary school (Bliss, Chandra & Cox, 1986; Chandra, 1986; Chandra, Bliss & Cox, 1988). Their research looked at the factors that influence the implementation of microcomputer use in a school at the teacher, department and school levels. At the level of the teacher, teachers' experiences and views about computers and the use of computers in teaching were analysed; at the level of the department, heads of departments' computer policies were studied; and at the level of the school, distribution of resources and facilities were examined.

Using Lundgren's Frame Factor Theory (1972), they looked at the teaching process as determined by formal rules (i.e. strategies of the decision makers), organisational constraints and solutions, goals (i.e. the curriculum) and attitudes, views and opinions of the teachers. The decision makers' strategies and leadership styles were classified using White & Lippitts' (1968) set of categories, i.e. autocratic, democratic and *laissez-faire*. Teachers' perceptions of the use of computers were represented as driving or opposing forces using ideas of Lewin's Force Field representations (1952).

Their research established the importance of the interplay between the teachers' attitudes and the organisational constraints of the school. As they explain: "(organisational) constraints provide the boundaries wherein teachers develop their ideas or change their attitudes about the use of computers in teaching" (p. 61). They describe seven different 'types' of

teachers: (1) favourable, (2) critical, (3) worried, (4) unfavourable, (5) antagonistic, (6) indifferent and (7) uninitiated. The existence of favourable, 'keen teachers' who make themselves available, at their own personal time cost, to stimulate and help others, was found to be a decisive factor in at least one of the school's departments. No clear pattern was identified in the perceptions of male and female teachers.

The authors found a number of factors influencing uptake. Changes to the existing role of the teachers were an important issue. Bliss et al (1986) categorised those changes into three broad areas: changes in themselves being an authority (i.e. being confident), changes in themselves as an authority (i.e. being competent) and changes in their teaching situation. Teachers showed anxieties and feelings of inadequacy because of the need to master a new and complex area of technology, and about the amount of commitment required in terms of time and energy to feel confident in this area. Some of the teachers perceived themselves, by their personality or abilities, as not being able to acquire this new expertise. They saw themselves as not 'logical or mathematical', 'too old' or 'too set in their ways' for this new educational technology (Chandra, 1986, p. 305).

Teachers' attitudes, according to Chandra (1986, p. 289), might be considered all important in determining the uptake of computers and this may be the case in the short term. However it would seem that for the long term, additional positive forces such as 'strong leadership' are more important determinants. Autocratic leadership was effective in initial stages but a *laissez-faire* style served needs when teachers perceived those needs. Organisational constraints were seen by teachers as barriers, which many of them felt could not be removed individually, but which needed co-operation from staff 'above' them. Among organisational constraints, teachers mentioned lack of training, lack of hardware and software resources, inappropriate school time tabling, lack of time and class size.

Ellis (1986) worked with teachers in an elementary school in Sheffield and later tested his results in four other schools. He found three groups of factors closely associated with the use of computers for teaching: the management of computing resources throughout the school, in-service teacher training and the involvement of parents. Computers, he asserts, should be easily accessible and transportable and teachers should be kept continuously informed of all available resources.

Olson & Eaton (1986) worked with eight Ontario schools to investigate how teachers were using computers in the classroom. Discussing computer use as an innovation process, they point out the different nature of procedures, such as drill and practice, that "do not appear to strain existing routines too far", and others such as LOGO which "is not seen as fitting in with familiar teaching routines" (p. 32). They call the former 'routine' procedures and the latter 'novel' ones and go on to argue that 'novelties' have more complex and longer implementation processes because "teachers

cannot be expected to suddenly abandon their practice in favour of teaching activities quite remote from what they are used to" (p. 32). This approach seems to coincide closely with and Doyle & Ponder's (1977) discussion of 'congruence' as a crucial characteristic of the innovation.

Olson & Eaton studied the cost-reward structure of teachers' computer use. For this, they used a distinction developed by Harré (1979) between 'instrumental' behaviour (which is directed at producing student learning) and 'expressive' behaviour (which is directed at creating respect for the teacher and the subject). This distinction, the authors say, is necessary to understand teachers' responses to innovations. They mention, as an example, the use of LOGO by teachers who do not find it particularly useful or relevant but in this way hope to be seen as appreciating the social needs of the students (p. 35). They argue that "this analysis of the symbolic elements of teaching is important because it is part of coming to understand what an innovation means in practice (for the teacher)" (p. 35).

In probing teachers' views they found that one of their major concerns was based on the challenge to the well established ground rules for providing guidance and maintaining discipline in classrooms. The management of episodes where students required individual support while working with the computer, was a 'novel' procedure. Teachers spoke about a wide range of possible causes for students' delays (such as unclear error messages and software or machine breakdowns) and how these situations affected class planning.

The authors listed a number of barriers to implementation: (a) insufficient supply of appropriate software, (b) increased workload necessary to use computers in the classroom, (c) insufficient access to hardware, (d) technical problems with the computers, and (e) slow replacement of consumables.

Studies in the Latter Part of the 1980s

Eraut (1988) studied the managerial aspects of the use of computers in UK secondary schools. He found substantial variations in teacher uptake. He suggests an interpretation based on the presence in the school of 'cosmopolitan' teachers. He describes them as teachers who seek out opportunities for change, enjoy risk-taking and are willing to work with new methods of learning.

Heywood & Norman (1988) used attribution theory (Kelly, 1983) to study the concerns of a group of 28 teachers in four London primary schools about the use of computers. They concluded that teachers' concerns were related to a lack of confidence and competence in their own ability to use computers. They stress the difference between confidence, as a formative unstable state, and competence as a summative stable state, while showing their close relationship. In further discussing the problem of lack of

confidence they argue that the concern is not based on a lack of confidence in the capability of technology to allow the teacher to implement a particular teaching strategy but rather on a lack of confidence in the teacher's own ability to implement it. They found that non-users did not state an increase in their workload, machine breakdowns or access to the computers as significant reasons for non-use. Taking recourse to innovation theory, Heywood & Norman point to the absence of curricular strategies to support teachers as a major factor in determining uptake. Teachers, the authors say, lack competence in perceiving a place for computers within the existing curriculum and implementation will not take place until they find such a place.

The Pupil Autonomy in Learning with Microcomputers (PALM) project (Somekh, 1989) attempts to overcome barriers to IT innovation through action research. The project's approach is to "invite teachers to make judgments based on evidence", thus stressing the lack of evidence of the real value of computer use as a major factor in teachers' reluctance to face the challenge of using the new technology.

The PALM project identifies barriers at the personal and institutional level. At the personal level they list: (a) a teacher's self-image may conflict with the innovation (e.g. being a 'non-technology' person, (b) a teacher's concept of teaching may put little value on change as opposed to expertise (this is usually associated with the belief that learning is the responsibility of the teacher rather than the student), (c) an anxiety felt by the teacher, based on a feeling of incompetence (which they may feel ashamed to admit to the students), and (d) teachers often experience frustration at technological failures that jeopardise a class session. At the institutional level they found: (a) insufficient access to the computers for the teacher out of class time which impedes their own personal process of making sense of the innovation, (b) insufficient teacher time to reflect on the use of the technology and engage in professional dialogue, and (c) logistical barriers based on complicated rules for the provision of consumables such as printer paper or diskettes, for instance.

McCoy & Haggard (1989) carried out a survey-based study of the use of computers for instruction in 26 US schools involving 112 teachers. They found that only 7% used computers 'intensely', 32% 'regularly', 36% 'occasionally' and 25% did not use them. To examine the determinants of computer use, this variable (degree of IT use) was regressed on: gender, level taught, years of teaching experience, confidence in personal ability to use computers and perception of the value of computers in education. Their results showed that teaching experience was significant in predicting computer use while the other variables were not important. Shultz et al (1989) studied the use of computers by secondary school mathematics teachers in a midwest urban district in the USA. Their sample of 200

teachers was randomly selected from a total population of 325 mathematics teachers.

Some of their findings supported conclusions drawn from previous research. Approximately 90% of the teachers felt that computers were very useful for teaching (p. 8). However less than 25% of them were regular computer users. Teachers felt that the school and the district were not providing guidelines for using computers with specific curriculum topics. They also called for more hardware and software relevant to the curriculum. Some teachers felt that using computers would reduce the already scarce class time available to cover the present curriculum. Non-users mentioned the issue of computer room scheduling and having to move to the computer room as a major reason for not using them.

Gillman (1989) carried out a metasynthesis on computer assisted learning (CAL) research studies about the adoption and implementation of computers in schools. Citing work by Adkisson (1985) he says:

> ... (when compared with principals or governors) teachers, as a group, are the most conservative with respect to the acceptance of microcomputers ... as practitioners, teachers have already developed adequate solutions to their pedagogical problems ... many teachers are reluctant to invest additional time and energy to incorporate a new technology into their methodology. (p. 3)

Gillman cites findings of Schimizzi (1983) and Rogers et al (1985) who stress the role of the principal:

> ... whereas individual teachers often act as innovation initiators, schools principals must take responsibility ... because as leaders and managers, only they are able to manipulate the incentives to facilitate adoption and implementation ... also the establishment of new facilities and support services represents an important change in the school's organisational structure ... and adequate compensation and incentives (for the teachers) are evidently not being tendered. (p. 5)

Referring to teachers, Gillman argues that innovators require "unpressured exposure to new ideas along with adequate time to assimilate, experiment and practice new procedures" (Winner, 1983). Concerning teacher education, the most important finding, according to Gillman, was the fact that there is no difference in profiles of concerns between teachers who have received in-building, informal computer training and those who did not receive such training (Wimmer, 1984). The implication being that unless such training is geared to the specific needs of the individual teachers involved, there will be little or no impact on their competency to use the technology.

Teachers do not use computers, says Gillman, on the basis of Johnson's findings (1986), because of "lack of access, lack of funding, lack of participation in the decision making process and lack of time for learning".

The 1990s

Blease & Cohen (1990) conducted an ethnographic study of the introduction of computers in a primary school in the East Midlands of England. They assert that the fundamental change required to use computers for teaching is to teachers' existing conception of the teaching-learning process and of their pedagogic role within it (p. 29). This, they argue, explains why some teachers use the new technology more readily than others. They found, at the beginning of the study, that the teachers' "lack of confidence in themselves as computer users" (p. 33) was the main factor in their reluctance to consider computers as part of their professional repertoire. A major part of the confidence problem of teachers was related to the fact that they felt less competent than some students in using computers.

Rhodes & Cox (1990) studied the use of computers in a group of twelve London primary schools from 1985 to 1989, with particular emphasis on the influence of teacher training upon uptake. They found the development of computer use in the schools to be influenced by four major factors: the attitude of the headteacher, timetabling arrangements, teachers' attitudes to the technology and the fabric of the school building.

Teachers' acceptance of the value of computers for teaching did not lead, in their study, to regular use. Teachers mentioned several obstacles to the use of computers: the increase in workload they believed would result, the lack of good quality software, and physical difficulties such as finding the right plugs and reorganising the classroom for co-operative learning. Computer use was much higher among male than female teachers. The uptake was highest in schools where the headteacher had actively promoted the use of computers and where the use of computers had been formally timetabled. Computer use was not found to affect teaching style.

Teacher training was a major part of the Rhodes & Cox study. They found that short INSET courses were not very effective in promoting uptake and that teachers need an ongoing training programme. A major problem was the assumption that, with courses concentrating up to 97% of the time on technical aspects, teachers would be able to use the resource effectively in the classroom having spent only 3% of the time discussing educational applications. Even teachers who used computers regularly felt the need for additional training.

Plomp, Pelgrum & Steerneman (1990) applied a combined case study-survey methodology to investigate the use of computers in 28 Dutch junior secondary schools. They found that:

> In the majority of the schools computer developments - even when they have lasted for several years - are very modest ... and one cannot speak of any real integration of computers in the school curriculum ...

> computer use has a low frequency and is applied for a small percentage of the subject matter.

In a subsequent stage of the study Plomp et al looked for an explanation for these results and tried to identify "which factors determine this rather disappointing picture" (p. 164).

They identified a number of factors as barriers to a more integrated use of computers in teaching: (a) the lack of a clear school policy on what the institution wants to achieve with the new technology and how it should be achieved, (b) lack of hardware, software and curricular materials, (c) lack of time for the teachers to get acquainted with the new technology, and (d) lack of a continuous process of staff development. Teachers who used computers regularly rarely mentioned a specific educational need as a justification; in most cases they referred to more general aims such as to increase motivation, to try new technologies or to meet future needs of society. Principals asked about the reasons for introducing computers in the school also rarely made reference to specific educational needs and mentioned mainly rivalry with other schools and interest in implementing new teaching strategies.

Plomp et al conclude by speculating that

> ... different educational actors seem to be waiting for each other. Schools wait for teachers to start activities; teachers, however, wait for a policy at school level. Both schools and teachers are waiting for a policy at national level ... and innovation plans at the national and school level pay little attention to factors which are known to influence the implementation of an innovation. (p. 169)

Finally, mention must be made of the extensive International Association for the Evaluation of Educational Achievement (IEA) 'Computers in Education' survey, the results of which are reported in the book *The Use of Computers Worldwide* (Pelgrum & Plomp, 1991). This contains a wealth of information on computer use in the 21 countries which participated in the study, including the availability of hardware and software, the reasons why and the purposes for which computers are used, staff development and training, attitudes of principals and teachers, and gender equity in relation to computers. Some major findings of the research were that in many countries most schools do have access to computers but that there are great differences within as well as between countries with respect to the availability of computer hardware and software; in many countries only a small percentage of teachers in secondary schools are using computers (an exception is the USA where almost half are using computers in their lessons); staff development activities consist mainly of introductory and application courses rather than pedagogical/instructional aspects; educational practitioners have very positive attitudes about the use of computers in education; and that in most countries, computer use in schools

is male dominated (exceptions being the USA, Hungary, Israel, Poland and Portugal).

From a master list of 29 'problems in using computers/reasons for not using computers' used in the study, teachers most frequently quoted lack of hardware, lack of software, problems with finding enough time to learn about computers, and lack of time to prepare lessons using computers. Elementary school teachers also frequently mentioned lack of knowledge. In the case of the data for Holland and the USA, a model linking hypothesised explanatory factors (taken from other research) to the implementation of computers in school education was analysed using a technique known as linear structural relations analysis. The model for the USA was successful in predicting 50% of the variation in computer implementation between schools, the main predictors being staff development policy, software-hardware availability, innovation experience and external support. But for Holland the hypothesised explanatory factors were unable to satisfactorily predict computer implementation. The report concludes with the observation:

> Real innovative changes can only take place when good quality software products are available and teachers are well acquainted with these products (by being trained in using them and integrating them into their instructional approaches). Our data shows that these two conditions are hardly fulfilled: lack of software and lack of teacher knowledge and skills are among the most important problems encountered in using computers.

Concluding Remarks

General

This literature review attempts to portray the main developments in the recent study of planned educational change with special emphasis on the introduction of computers in schools. The studies reviewed examine the nature of the innovation itself, the attributes of the teacher as a potential user of the innovation and the context in which the innovation is to be implemented.

Most of the research on change of this kind in schools before the 1970s focussed on technical aspects of innovations. A majority of the studies of that period concentrated on the resistance of individual teachers, which was perceived as the main factor in the process of change. Overcoming this resistance was perceived as dependent on providing technological access and showing the technical advantages of the proposed innovation (Gross et al, 1971; Fullan, 1985).

In the last two decades a number of increasingly convergent insights into the process of change have developed. The need to study the teacher in the context of the social organisation of the school, rather than as an isolated agent, has been emphasised. Teachers' dependency on their formal leaders (e.g. principals and heads of departments) to overcome some categories of constraints imposed by the very structure of schools have been discussed by authors such as Gross et al (1971), Fullan (1982a), Huberman & Miles (1984) and Chandra (1986).

The previous emphasis on the technical characteristics of the proposed innovation has evolved into a more context-sensitive approach focussing on how the proposed innovation fits with the teachers' working conditions and value systems. Authors such as Doyle & Ponder (1977), Brown & McIntyre (1982) and Cuban (1986) found that the clarity, congruence and costs of implementing an innovation are crucial to uptake.

Teacher Education

Computer innovation in schools is not, we feel, a topic of any great priority for teacher trainees. In initial teacher education the emphasis should be on developing classroom competence with information technology and encouraging student teachers to think critically about its role in teaching and learning. Problems of institutional innovation and change are far more likely to be the concern of school principals, senior managers, regional or national advisers, curriculum development agencies, and government ministers. Hence, the literature reviewed in this article is most directly relevant to in-service education and professional development for senior personnel in the education services. It is also of relevance to teacher educators, who need to be sensitive to the school contexts in which student teachers may be working.

Two messages that emerge for these audiences are as follows.

- Factors affecting computer innovation are often the same or similar to those affecting other innovations. Much can be learnt from other attempts to implement change even though the subject and context may have been rather different.
- Change is rarely simple! The literature reviewed here points to numerous influential factors which constitute a complex system of variables that interact. These are summarised in Table II.

A more extensive account of some of these factors, especially as they relate to innovations in general, can be found in Grunberg (1991).

Critical examination of the factors identified in Table II, informed by the research reviewed here and by exchanges of personal experiences in different school contexts, is potentially a useful in-service or professional development activity for all those with responsibilities for the initiation and management of change in educational institutions.

Characteristics of the Innovation
Perceived need for the innovation
Reliability
Clarity
Congruence
Cost
Characteristics of the Teacher
Personal characteristics (e.g. gender, age, experience)
Self-image
Views of teaching and of computers in general
Views of the value of computers in education
Views of the impact of using computers in their work
Confidence and competence in using computers
Previous experience in using computers
Characteristics of the Institutions
History of innovation attempts
Teacher participation
Computer INSET (in-service education and training)
Lack of time for reflection, practice and interaction
Aims of the school IT policy
Support structure
School internal communications and information systems
Principals' and heads of departments' actions
IT resources management (e.g. time-tabling, logistics)
Level of provision of hardware and software resources
Training of principals
External Characteristics
Parent and community support
Role of the government

Table II. Summary of factors affecting innovation in schools with particular reference to the introduction of computers.

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