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The potential of information technology in support of teachers and educational managers managing their work environment

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The use of information technology (IT) to support the classroom teacher and school managers to organize and manage the learning environment better has received little specific attention, even though many applications or systems purport that this is one of their aims. This special issue attempts to fill that gap. This introduction paper provides an overview of the range of support that IT can provide in the field of education, and discusses how the development of these support systems needs to be approached analytically. Finally, there is an overview of the papers invited for this edition of the journal that are illustrative of the wide ranging development of IT to support teachers, teaching and the management of both.

KEYWORDS: Information technology; educational management; pedagogy; methodologies.

INTRODUCTION

Much has been written about how IT fits into the school curriculum and the role of IT in learning. However, the role of IT in supporting teachers and school managers to manage their work environment has received much less attention as a specific aspect of education gain through IT use. The National Council for Educational Technology in the UK has published many documents about IT and learning. One such document resulting from a discussion conference on the future curriculum with IT is clear about the potential impact on learning:

> "IT encourages and enables certain learning processes to take place in more contexts and for a wider range of purposes than was previously possible. It was felt that IT works against current orthodoxies in that it supports learning which is intuitive, inferential and often tentative: it 'unformalises' the formal." (NCET, 1993, p. 23).

The discussion group went on to conclude that:

> 'Some of the qualities of IT which were identified within the seminar as being of importance to the curriculum were generic. Amongst these were the principles that IT enables its users to transfer information and data from one source to another, to redraft and to transform that information. IT offers speed, accuracy and quality. Thus computers can generate plenty of data, and the patterns and hypotheses which are generated as a result may stimulate further investigation. IT can provide feedback, support and privacy when required. It can also foster team work. It can enable its users to create quality products. It can enable learners to build on the knowledge of technology that they have developed outside the formal learning environment and offer a variety of choices for their learning. It has the potential to help children to cross cultural boundaries through extending their experience and widening their horizons.' (NCET, 1993, p. 24).

In 1986 Saunders described IT as 'revolutionary in that it puts learning into the hands and control of the learner' and Her Majesty's Inspectorate observed in 1989 that 'the nature and balance of much work within the curriculum are likely to be radically changed, . . . Compared with current practice there is likely to be increasing emphasis on the quality of communication; and greater stress on high-level thinking, on interpretation and on creative expression.' (DES, 1989, p. 7).

What a panacea of opportunity is described as a result of observations on current practice and reflecting on opportunities for the future. However, such change from the formal to the informal, to higher level thinking, in handling vast amounts of data at higher speeds of access and supporting a variety of choices in learning will put great pressure on the management role of teachers, and the management tools of organizations. For example, recording and reporting processes that are already putting teachers under great pressure in the era of 'accountability' and the greater flexibility afforded by IT to provide independent learning pathways will vastly increase this pressure unless additional support systems are introduced. It seems obvious therefore that the IT tools must also be developed to support the new information needs of teachers and administrators, and provide additional management support, in parallel with the developments of IT as a learning tool. The processes of such development may be random and haphazard but many research groups around the world are using more logical and evaluated approaches to ensure that there is real benefit to the education of pupils. The papers in this special edition provide an opportunity to view both examples of good current projects and the research methodologies used to ensure that there are real gains resulting from the extensive investment in IT, and to see if the potential gains are becoming reality. It is possible that the gains are not clear or have such small effect that, as a community that improves through reflective processes, we need to question the basis of the changes being considered through the application of IT.

DISCUSSION

A framework for analysis

In assessing the value and impact of IT systems and applications supporting teachers, managers and administrators, it is necessary to have a clear analytical framework (see Fig. 1) that considers features of:

- the strategy used for the design and development of the IT applications;
- the IT applications;
- the approach for the implementation of the developed systems, e.g. the training of system users, and
- the organizational features of the institutions into which the IT applications are introduced.

The four groups of factors impinge on the way and extent of use of the developed system by teachers managing the learning environment, and by school managers running their organizations. System usage in itself leads to certain (un)desired, positive or negative effects.

The variable groups in Fig. 1 are interrelated, a choice in one block has consequences for what happens in one or more of the subsequent blocks. Neither the system quality nor the implementation process, or the features of the educational organizations alone can explain fully how a system is used and which impact system usage has. The combination of variable groups/variables is decisive for what happens.

Figure 1 has been developed by Visscher (1996a) to illustrate the factors and their

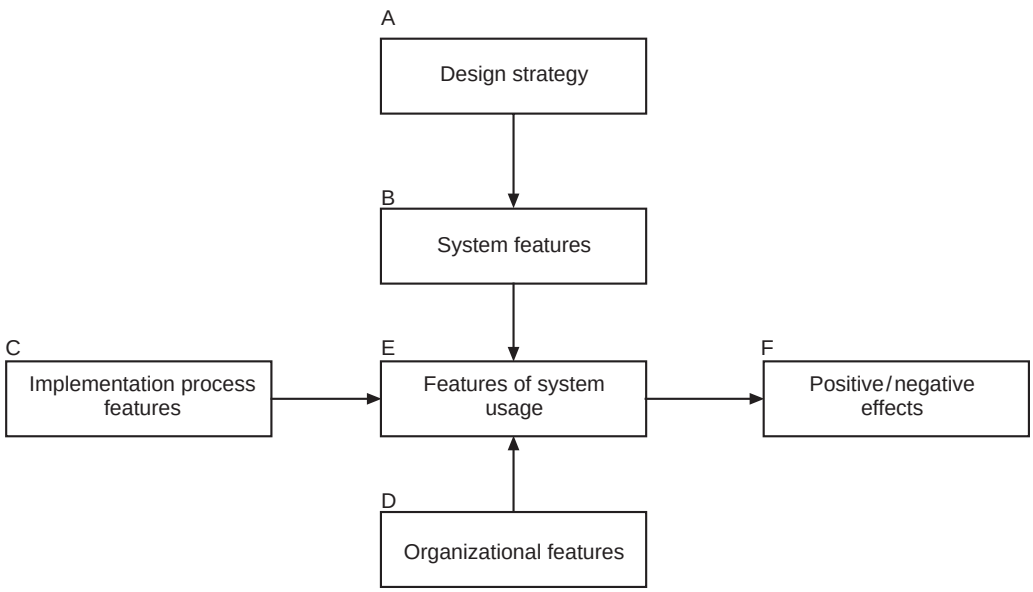

Figure 1. The variable groups influencing the usage and effects of computer applications

relationships in information systems designed specifically for the administration and management of education (now commonly known by the acronym ITEM, i.e. information technology in educational management). There are, however, some important differences between the contexts of institutional management and classroom management support. ITEM systems, although used by classroom teachers in some implementations, do not impinge greatly on the teacher's classroom autonomy in how to teach, which is a very personal experience linked to developing relationships with pupils. Systems more particularly designed for the classroom will have to fit in with a very wide range of teaching styles. That is not to reduce the importance of personal management styles, but information provided by ITEM systems to support managers leaves a large autonomy in how the information is used. There is a danger that supporting classroom management of learning will try to impose methods of working dictated by the information needs of the system, which might be quite alien to the teacher and hence reduce transportability between users.

Assessing the main impact of systems for the classroom is also more of a challenge as measuring learning gains, particularly in the time scale required by many projects, is fraught with problems due to the very wide range of variables in individual pupils, classes, classrooms and teachers that need to be considered that are far less determinate than many outcomes from ITEM systems. However, having identified these differences, the similarities between both contexts are such that Fig. 1 has been used as a common framework in briefing the authors on aspects to be considered while writing the papers for this special edition.

Information technology in support of educational management

The use of computerized information systems for the administration and management of educational institutions has grown rapidly since the 1960s when the first business applications, e.g. finance and payroll, were developed in the USA (Visscher, 1991). A decade later enthusiastic teachers in a number of other countries, e.g. Hong Kong, UK and The Netherlands, started to develop the first, tailormade, amateurish, administrative programs for their own schools. Some years later software vendors entered the market producing new applications, or improving the software that had been developed by teachers. In the 1980s a few countries progressed to the design and development of school information systems consisting of integrated modules, and enabling simple analysis of relationships between data, e.g. between student and personnel data. In the developed countries many educational institutions benefit now from the computer-assisted recording, processing and production of data. In most cases this concerns computerized administrative work: the computer-assisted registration and processing of student, finance, personnel, resources and timetable data, and text management.

Despite the availability of very powerful integrated management information systems in a number of countries for the assistance of managers, by providing them with valuable information through the analysis of trends in data and 'what–if' simulations to inform their school policy, e.g. capacity, financial–economic and curricu-

lum planning, and to evaluate the effects of the policy measures taken, their use is still very limited (Visscher, 1996b). It is plausible that this problem is due to the fact that this sophisticated management usage requires:

- the capability to decide which information is needed,
- the technical information retrieval ability,
- the ability of data interpretation,
- a willingness and capability to use the information in decision-making,
- an evaluation of the effects of system usage in the managers' own institutions.

Historically, the use of such facilities and information to support management functions have not been available and hence the expertise and training remain limited even in countries that view themselves as being technologically developed. It is therefore not surprising that most of the developing countries are still in the initial stage of ITEM due to a lack of capable professionals, finance and the technical infrastructure needed to support the system usage beyond mere information storage and low-level retrieval.

However, there is growing evidence that the use of management information systems in educational institutions can lead to more efficiency and effectiveness in these organizations (see, for example, Fung *et al*., 1996; Barta *et al*., 1994). Efficiency improvement in terms of a better relationship between the input and output of resources is possible because, at the basic technical level, computer use enables the single entry and multiple use of data, computer-assisted data exchange and computerized data manipulation to provide information to match specific organizational and functional needs. In the precomputer era the same data had to be registered repeatedly by different staff, e.g. in the school office, by teachers, counsellors, deputy head teachers. The internal and external exchange of data often required the transfer of data to forms, and the manipulation of data was very difficult and time consuming with the result that, much of the time, it was not and still is not done.

The fact that the use of the computer enables efficiency improvements implies that the saved staff time and input can be used for other activities that may help schools to set and accomplish their pupil and learning related goals, which supports them in becoming more effective. The use of computerized school information systems can also influence school effectiveness in other ways and some examples of this already exist. If the computer enables the computation of alternative solutions for complex but structured problems with a limited number of solutions, e.g. the construction of the timetable, school staff can choose the solution they judge as the best one which is likely to have a positive influence on the motivation of students and staff. The software can contain predetermined expected standards with respect to truancy, student achievement, budgets and other 'management' factors. Any violation of these standards will result in the computer warning school staff that action is needed and as such increase the chance of a timely intervention, contributing to better operation of the school organization. Overall, a computer-supported school information system can be used for providing a basis for more informed policy development and evaluation and as such enable a more effective functioning of educational institutions.

Information technology in support of classroom pedagogy

There is a range of thinking on teacher support applications that can, or will in the future, support the teachers more directly in the classroom. The developing support systems can be categorized into those that are designed specifically for aiding the teacher through the better flow of information either to the pupils through better worksheet production through wordprocessing and such packages as Science Education Advisor (Khan and Yip, 1996) to support the creation of lesson plans or to aid decision-making and pupil support, such as the result of the data and information supplied by ITEM systems, usually in printed format. Secondly those which link more proactively between pupil learning and the support of the teacher with the transfer and analysis of data on pupil progress, such as the immediately available comparison of new progress data with old for immediate feedback to pupils or class via classroom based network facilities. A third category is developing which supports the teacher more directly through the management of the learning process itself, and hence links directly to the pedagogy of the classroom, such as the integrated learning systems described in this journal. As the systems mature the differences will begin to blur and it might be envisaged that further integration will occur, especially between what can be seen as organizational infrastructure and pedagogy through the more integrated nature of available information between ITEM and teaching-based systems. For any part of this vision to be implemented effectively there will be some preconditions that have to be met and no country, or even individual school, yet fulfils enough of the preconditions for wide adoption of such systems.

It is obvious that the end result should be the enhanced learning environments through better pedagogical practice in the classroom and better learning by pupils/students, otherwise the investment in time and money will not be worthwhile and could legitimately be questioned. It is unlikely that all developments will show success as is the unerring nature of research and development in such previously unknown learning environments. However, the continuing advances in technology will provide enhanced integration of IT into teaching and learning that is guided by previous successes and mistakes. The rate of improvement should therefore accelerate and it is important that we identify and investigate aspects of IT that show potential and relate them to implementation requirements and known successful pedagogy.

A taxonomy for IT support of pedagogy

In dissecting the model in Fig. 1 in relation to actual classroom practice, it is possible to identify aspects of essential preconditions, the IT tools, systems and applications, the organizational infrastructure, both explicit and implicit, and how the IT might be expected to impinge on the classroom pedagogy that can be mapped onto the identified factor. At this stage, and in the space available, it is only possible to list indicative example items to identify the range that might be considered pertinent and briefly identify how these aspects are related to the variable groups A–F for evaluating the influence and success (or otherwise) of computer applications. Table 1 shows such an indicative list of possible contributory items under the four

Table 1. A taxonomy for IT supporting teachers and educational managers

Examples of preconditions	Examples of tools–systems–applications	Examples of infrastructure	Examples of pedagogy
Easy access to facilities	Computer-based instruction	Curriculum ethos	Student led
Critical mass of IT facilities	Computer-aided learning	Curriculum content	Teacher led
Teacher time to learn	Integrated learning systems	Management ethos	Computer led
Teacher/pupil competence	Expert/knowledge-based systems	Monitoring/auditing pupil activity	Managing interaction
Teacher/pupil IT skills	Administrative support systems	Learning context and environment	Intervention
Teacher/pupil competence	Executive support systems	Administration of information	Pupil motivation
User acceptance	Decision support systems	Pupil assessment	Pupil activity
Relevant model of learning	Management support systems	Record keeping	Ownership of work
Actual or perceived need	Group support systems	Finances	Level of learning
Relevant training	Communication systems	Resource management	Discussion
Support of senior managers	Internet	Strategic planning	Reflection
Technician support	Multimedia	Feedback systems	Feedback systems
	Wordprocessing	Reporting	Reporting
	Spreadsheet	Timetabling	Learning partnerships
	Database	Registering/attendance	Collaboration
		Organizational structure	Autonomy

headings identified above. The table is not intended to show any linkages between the items in the four lists (of which there are many) but merely to illustrate the wide range of applications and variables that could impinge on the support of teachers in the classroom. In particular, it is useful to bear in mind the influence on teaching styles that might be identified by teachers as both of a positive or negative nature depending on the prevailing culture of the classroom, such as pupil autonomy and the concept of pupil- or computer-led working practices.

Preconditions (variable Groups B and D). For any innovation to succeed there must be some preconditions that make the organization or individual susceptible to accepting the innovation. Preconditions are the required aspects of the organization and day-to-day functions of the organization at the time that the IT systems (already designed) are installed and the implementation process begins. Preconditions are a static feature at that point in time and have perhaps been previously assessed as a known starting point.

The preconditions can be both organizational (variable Group D) and the features of the IT system being introduced (variable Group B) and might relate to the extremes of organization as a whole or to individuals within the organization or more realistically a combination. For adoption by teachers there must be intrinsic motivation through perceived or actual needs. The list of preconditions shown in Table 1 are examples of those that might need to be taken into consideration in developing the implementation process (variable Group C). For example, the NCET (1994) found that 'headteachers who use computers raise the profile of IT in their schools' (p. 26) and 'giving teachers easy access to computers encourages and improves the use of IT in the curriculum' (p. 25) suggesting that a headteacher who leads by example and provides easy access to computers for the teachers could be seen as providing a precondition for success. Johnson (1993), although looking more directly at pupils' learning, provides further evidence of useful indicators in his research such as 'there was a minimum threshold of IT access' (p. 164), ''The outcomes of pupils' learning were substantially influenced by teaching. Selected aspects of organisation, management, teaching styles, ... And pedagogical practice and their links with the effective use of IT were found to be important contributors'' and 'inservice provision was also identified as a major concern' (p. 153). In addition, although some limitations of the research were identified, there was a clear suggestion that the impact of IT was related to the level of computing resource, which indicates that when IT is in the role of supporting the management of learning then this precondition will impinge on variable Groups E and F (Fig. 1) through the way that variable Groups B and D are moulded together through the implementation design. More recently, inservice and preservice training and resourcing has also been identified in an independent inquiry in the UK (Stevenson, 1997) as of major importance in widening the use of information and communication technologies (ICT) in schools. The inquiry concluded that 'both initial and in-service training need to take fully into account the need for confidence and competence in the application of ICT in schools, ... Ways should be found of making computers available to teachers to facilitate the learning process. Teachers rapidly become enthusiastic once they have

regular hands-on access to computers' (p. 7). It is evidence such as this that has been used in compiling the indicative list of preconditions in Table 1.

Tools, systems and applications (variable Groups A and B). The papers in this special edition are illustrative of the wide ranging IT applications that are being developed and used to support the management of teaching and learning in the classroom or those that point in the direction of what might happen in the future. Although when most teachers first receive and start using the 'systems' in the classroom the design process has been 'completed', it is important that the design process for the classroom environment includes classroom practitioners to provide feedback, and many failures have been reported where user involvement and user acceptance evaluations have not been carried out (Wild, 1996). The items in the table are again illustrative of the wider range than those just represented by the papers in this journal that teachers might call on for support in managing particular aspects of institutions or classroom pedagogy, ranging from a now widely used basic application of wordprocessing for producing teaching materials that can be more easily individualized to the yet more experimental expert or knowledge-based systems being investigated to support teachers in identifying pupils' misconceptions (Abdullah and Wild, 1994).

Infrastructure (variable Groups C and D). Organizations are dynamic systems with both implicit and explicit infrastructures. Designing an implementation process to marry a new IT system with an organization can lead to a remoulding of the overall infrastructure, with both implicit and explicit aspects of the organization being changed to ensure successful outcomes. Obviously, as the dynamic changes to the infrastructure take place, there will be a tendency for the original preconditions to be superseded through the identification of further needs, or at least given greater prominence and solid foundation for future IT system implementations due to preconditions being better met. There is therefore always going to be some overlap between preconditions and infrastructure due to this dynamic environment. Therefore, the features of the infrastructure can both influence the acceptance and success of the innovation and be influenced by the innovation. ITEM systems in particular are likely to influence the information infrastructure strongly that will affect staff roles and responses in the classroom through an enhanced information infrastructure, such as better availability of pupil records, and will enable teachers to make better informed decisions concerning individual pupil support. However, acceptance of the IT into a classroom situation can depend on the prevalent curriculum and innovation ethos of the school at the time of change, which must be considered as part of the input to the design of the implementation strategy that itself will be informed by previously evaluated preconditions that exist in the organization.

Pedagogy (variable Group E). The influence on the classroom pedagogy can be both direct and indirect. Providing better information and supporting teachers to manage information through ITEM systems should, in itself, provide more time for pupil contact. This should enhance interaction, positive intervention, feedback and discussion with implications for a more collaborative learning environment. In

addition, applications that automatically provide information on pupils' progress helping the teacher to manage the learning in a more individualized way, gives a potential for individual 'learning pathways' that affect motivation, and hence level of learning, through enhanced feedback structures. All the aspects of pedagogy shown in Table 1 can be influenced by the use of IT at the basic level of classroom interaction, and all can be identified, with suitable teacher input, with active learning environments. For example, Rogers and Wild (1996), in researching the use of IT in science teaching, reported that 'when IT is used, the pattern of activity tends to show a shift in emphasis away from time spent on preparing, measuring and reporting towards more spent on observation and discussion'. Such reflection and evaluation of classroom practice leads to a measure of the gains (or otherwise) through using IT, resulting in a measure of variable Group F in Fig. 1.

At its most fundamental level, IT must be seen to be part of the redefinition of the role of the teacher. Many writers comment that the teacher will no longer be seen as an authority on content or simply as a deliverer of information that is eventually assimilated into knowledge but as an enabler of learning. However, we must consider that, in the eyes of the student, the enabler could be identified as the computer. Like the blurring of infrastructure and pedagogy, there will be a blurring of who or what is enabling the learning to take place, with a seamless bi-directional transfer of information between computer and teacher. The maturity of decision-support will provide the teacher with information already manipulated into knowledge to which the teacher can quickly respond, as suggested by the paper by Vlug in this issue. In this way, teachers will be able to support the pupils more quickly and individually. Further enquiries can be suggested (and even directed) by the teacher, with the more rapid progression to higher level learning becoming the norm, with 'what if . . .' investigations being realistically proposed, for example in using databases or spreadsheets, and wider trawls of information being within immediate grasp in the classroom when needed, such as with the multimedia and Internet facilities now increasingly common in schools.

However, if this progress is to be made in the pedagogical use of IT then 'there will need to be more extensive thinking on philosophical issues relating to IT' (NCET, 1993, p. 28). In addition, there is a danger that to strive for such tight management will be to neglect the social environment of learning that relates to the more hidden curriculum in schools. We are not yet at this stage on a wide scale but the papers in this special issue suggest that the philosophical and social debates need to begin.

An overview of the papers in this special issue

The special issue covers a wide range of computer applications in educational settings: the support of instruction by means of integrated learning systems (Underwood), the assessment of progress in student achievement (Vlug), assistance in the initial training of teachers (Jennings *et al.*), strategic planning in universities (Rodríguez-Díaz *et al.*) and, finally, virtual organizations in the information space (Taylor *et al.*).

Underwood describes the nature of integrated learning systems (ILSs) by explaining how ILSs can assist in the management of learning, and what their management presupposes. She stresses that the term ILS covers a group of systems that differ fundamentally concerning the level of management and the control of the learning situation, e.g. the degree to which ILSs differentiate instruction depending on the ability and skills of the student. The strength of her paper lies especially in the research findings she collected during a three year study that has been aimed at evaluating impact under certain system user conditions. This study shows the effects that the use of ILSs can have in terms of financial resources, the management of learning and the control of the teaching–learning process. The use of certain ILSs radically influenced the pedagogical practice of teachers in terms of their beliefs, attitudes and teaching activities.

Jennings *et al*. refer to the use of telematics for instructional purposes specifically in the initial preparation of teachers. The authors describe their attempt to investigate whether a telematics learning environment can be designed that fits in a social constructivist paradigm, and that improves student learning. The telematic environment consist of video-conferencing to supervise student teachers during school-based work without visiting schools, and a website as a source for shared knowledge, and for promoting students' independent and self-directed studies. The paper presents the results of the research in terms of the experienced difficulties and advantages of using telematics for the aforementioned goals. Jennings *et al*. show how the quality of initial teacher training can be improved by utilizing technology in a well considered pedagogical approach.

Vlug portrays in the third paper how the Dutch National Institute for Educational Measurement (CITO) developed and implemented a computer-assisted pupil monitoring system for Dutch primary education. The system can be used at teacher and at school level. It helps in the longitudinal assessment of students' progress, including locating and tackling students' problems. The strong psychometric basis (item response theory) of the system ensures that students are assessed according to the same standards and that data on pupil and class progress are reliable (in contrast with the regular marks from teachers). The CITO project shows that careful implementation processes are also important in the case of systems of high quality. The success of the whole project is clearly illustrated by the fact that 80% of the Dutch primary schools have already bought the system.

The next two papers of this issue do not deal directly with instructional activities. They are related to the functioning of organizations: real, physical, tangible organizations (the article of Rodríguez-Díaz *et al*.) and virtual organizations (Taylor *et al*.). In the fourth article Rodríguez-Díaz *et al*. outline the assistance that the so-called executive support system (ESS) can give in strategic planning processes in universities. Just like in the case of the CITO project, implementation processes prove to be crucial for the introduction of these systems. In addition to some critical implementation factors, the role of the information system features (hardware and software) is also stressed. In other words, this project is a clear practical illustration of Fig. 1 in this introductory paper.

The last paper addresses a topic that is becoming popular more and more: virtual reality. More specifically Taylor *et al*. deal with virtual organizations formed by interconnected intellectual agents in the information space, enabling efficient commerce and communication (including education and training). In the view of the authors the technology for virtual organizations is already available in its elementary form and after becoming more sophisticated in the near-future will lead to the rise of this new type of organization. Taylor *et al*. illustrate the concept of virtual organizations by explaining what it may mean for a school district. An interesting question is of course what the implications of virtual organizations may be. How will education, for instance, be organized when business and the exchange and transfer of information no longer require that people meet each other physically at a certain place? Is there still a future for our schools, and if there is, what will that future look like? What will the social and psychological impact for the nature of future workplaces be? The strength of the paper of Taylor *et al*. is that it generates various questions and as such stimulates thinking about certain aspects of our future.

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