Using information technology to create new educational situations

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Information technology (IT) has the potential to create new educational situations in many different ways. To a limited extent, this potential is beginning to be realized.[1] However, there are many constraining factors. Our task is to identify which of them we can be most successful in manipulating so that the potential of IT to create new educational situations can be exploited.

It may be that the use of IT to create new educational situations is a more vigorous growth area in higher education or training in non-school settings than it is at the school-age level. However, because of the fundamental interest of countries throughout the world in improving the quality of basic education for their populace, I have focused on the school-age group in this article which is designed to stimulate discussion and debate rather than to present scientific conclusions.

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Creating new resources to support learning

INDIVIDUALIZING INSTRUCTION

Certainly a great deal has been hoped for with respect to the use of the computer as a tool to individualize instruction, notably within the traditional classroom environment. This may occur by using the computer to provide different routes and sequences of learning experiences to different learners, either within the same program or by facilitating the delivery of different sorts of learning experiences to students working in the same classroom.

At one level, the potential of providing individualized instruction within software has, in its realization, turned out to be little more than simple branching to help, extra practice or practice at a different level, based on the correspondence of student input with pre-expected responses. Other examples of this level, such as the Computer based programme (CBPA) System in Israel and the Computer Curriculum Corporation (CCC) in the United States, are more sophisticated not because they are more 'intelligent' about how best to respond to different learner characteristics, but because they offer large amounts of carefully sequenced material and have more features relating to automated control of the branching process than smaller-scale software of the same type. However, recent analyses of student interactions with the Israeli system show that even the most sophisticated of the currently available individualized systems are significantly limited in the accuracy, relative to student needs, of the individualization they provide (Hativa, 1987, 1988). The effectiveness of the individualization may be limited by technical decisions within the software. For example, with the Israeli system, in order to provide immediate feedback, an assessment of the student's input is made after each keystroke. The consequence is that keying errors are interpreted as conceptual errors and the student is branched accordingly. More significantly, however, the effectiveness of the individualization is limited by the still-primitive diagnostic facilities of the software.

In comparison with the CCC and the Israeli material, the majority of drill and tutorial programs available are even more restricted in terms of capability to interpret student needs and thus to select meaningfully sequences of content in order to individualize instruction. Many types of common errors are typically not anticipated, and in the relatively few programs that have tried to make a meaningful diagnosis of student errors in order to improve the relevancy of branching, the difficulty of the task has proved to be substantial.[2] Certainly, much work is going on, often under the perspectives of artificial intelligence or expert system research, but the output of this work is still small relative to its practical application. Probably the most successful applications have been in situations where there is a well defined but limited body of knowledge as well as inference rules relating to that knowledge. With the exception of Brown and Burton's early (1977) work on 'buggy rules' for the diagnosis of substraction errors, the most productive of these applications have been in specialized areas at the professional or at least the post-secondary level (see Dede, 1986).

Why has the capacity of software to individualize instruction as yet realized so little of the potential predicted for it? My own view is that this sort of realization is not going to occur, at least in the foreseeable future, on any level significant enough to compensate the effort and time necessary to make substantially more progress than we already have made. I do predict some valuable developments. I think work focused on better anticipation of common errors or misconceptions in a subject domain should continue and the results should continue to strengthen the learning involved with computer use in content-specific situations even as it strengthens our more general understanding of the learning process. I also think that content-specific programs may more routinely offer a wider variety of help options than are now typically available to the learner, in that we know that different learners prefer and do better with different types of learning aids and approaches.

However, I am sceptical about the potential of computers to intelligently individualize instruction, because for such potential to be realized we must know much more about the process of thinking and learning than we now do. Given the difficulty with which we have made even limited progress to understanding the learning process,[3] I predict only little realization of the potential of the computer relative to its delivery of meaningful, individualized learning experiences to the learner—at least until we know much more about the process of thinking.[4]

Another problem significantly limiting the potential of the computer to promote individualized instruction is independent of the limitations in our understanding of how students learn. As long as school organizational schemes remain the same, it is very difficult to accommodate differential acceleration among students. If learners are able to move through material at their own rates, a great discrepancy in current student level of achievement can soon occur. Then what? Experiences with programmed learning showed us that it becomes more difficult for teacher-reinforced, socially embedded learning activities to occur the more that students in a classroom are widely spread in the content they are studying. More and more instruction must then become individualized, a situation which becomes increasingly difficult to manage and, possibly, loses some important aspects of learning relative to interpersonal exchanges. The most obvious response to this is that traditional organizational patterns for education should be changed so that individualized learning can better occur. My opinion is that certain aspects of teacher-led learning situations, where students learn from each other and are aided in their learning by direct interactions with the teacher, are a desirable part of learning. The overall goal of individualized instruction is limited by this.

Thus my predictions of the extent to which IT can individualize instruction are conservative, for theoretical and practical reasons that I do not believe are amenable to much manipulation.

BRINGING THE OUTSIDE WORLD INTO THE CLASSROOM

With the use of modems, an expanded range of educational experiences is becoming available in the traditional classroom. They relate to either direct communication between students or access to remote information sources. Direct communication between students in different schools, areas, or countries is currently an area of intensive interest. The International Council for Computers in Education (ICCE), for example, sponsored an international symposium in August 1989 focused entirely on this topic.[5] Projects are in place around the world in which students in one location communicate with students in another, to learn more about each other's culture, as an experience in writing for a specific audience or for a specific purpose (often developing a joint 'newspaper'), or to exchange scientific data on common topics of exploration.[6]

What can be gained from this experience that cannot be had from sending information through the mail or by using the telephone? The major benefits are the immediate response time and the capacity for manipulating the information. Students can share in the preparation of material for telecommunicating in a way which is hard to envisage with a telephone conversation. Also, because of differences in time zones and the costs of long-distance telephoning, the use of the telephone as a communication tool in the school setting has never been very feasible. However, telecommunications is seen as having the potential of being a significant motivator for co-operative student projects.

Although considerable telecommunications activity is currently occurring in school settings, the amount of sustained activity beyond initial exploration is still very small. The most obvious constraints are financial and physical—it is generally complicated and costly to support a telecommunications linkage. In addition, the maintenance of these linkages and the technical support that teachers need to manipulate the system are also costly and logistically difficult. Even among projects that are part of centrally organized initiatives and where set-up, maintenance and support are supplied, the general use of these linkages is much less than would seem warranted by the potential. Technical problems continue, but more often it is pedagogical relevance that is lacking, so the experience becomes a one-time, interesting activity but one without enough substance to have much educational value. Management problems are also a major constraint on the use of telecommunications in education. For example, how does the teacher organize access to the system so that more than a few students can benefit from interacting through telecommunications? How does the teacher evaluate the benefit to students of such activities? How can the cost relative to the gains be justified? Are all the students in a class involved, or only a few? If the latter, what are the rest doing while the few are getting the telecommunicating opportunity?

I have more confidence in overcoming these problems than in overcoming the problems of building effective individualized instruction within computer-managed environments. Problems of cost and access will fade as natural market pressures make telecommunications more and more ordinary. The example of the telephone shows us that people can standardize and co-operate to create a common communications environment.

However, one thing may thwart the continued growth of computer-mediated telecommunications as we now know it: the rapid increase in the use of the telefax. For many types of information exchange, telefax transmission is more efficient and even more effective than file transmission through telecommunications, particularly for source documents. My prediction here is less confident, but I think we shall soon see the appearance of ideas for the educational uses of telefaxing, and that many of the exchanges we are motivated to do with computers will be handled more conveniently by fax. This will threaten the attainment of a critical mass of computers being used for telecommunications in the classroom, which may, in turn, prevent the substantial improvements in access and economies of scale that are necessary if such use is going to have any impact.

My predictions relative to educational focus and management of the telecommunication experience are based on the assumptions that we can find, document and disseminate good ideas about telecommunications use in schools. These good ideas have to include management strategies for teachers. I am confident that such ideas will continue to be found, and that the main issue is therefore one of dissemination of instructional strategies. We must begin by collecting information about existing practice as well as about existing problems. ICCE has adopted this as a priority service. Without attention to the implementation of telecommunications, experience confirms that its educational potential will just not be realized. It can, in fact, often become a negative experience because of the frustration and lost time involved relative to the little apparent educational gain.

GAINING ACCESS TO VAST AMOUNTS OF INFORMATION

Telecommunications can also be used to gain access to vast amounts of information. Through a subscription to one of the many public information services, students and teachers can access a range of newspapers, magazines and other source materials, more than could be available in physical form in any one school. Some of these commercial services offer special opportunities for student and school usage. An example is The Times Educational Network, operating out of the United Kingdom. The vision of the teacher as a guide for locating information rather than as the disseminator of information is dependent on access to large amounts of pertinent information. The use of on-line informational data bases would therefore seem to have considerable potential in terms of being an agent of change in educational situations, at least at the secondary level where students study world affairs and contemporary issues.

But this is another area where the full potential is not as yet being realized. The same problems that constrain the use of telecommunications for communications between students can also constrain its use for accessing information. The pedagogical relevance of accessing data bases is easier to describe than may be the case in using telecommunications for direct communication between students, and the power of accessing significant amounts of information easier to accept in terms of being educationally significant. Despite this, very few students have yet had any exposure to this sort of opportunity and probably only a very small subset of those who have make use of it in more than a limited way.[7] The technical and financial aspects of on-line searching are still a major constraint, albeit often more in impression than in fact, as the cost of using an information service in a judicious but productive and regular way can be considerably less than the cost of buying an additional computer.[8]

The major constraint here is one of orientation: we are not yet oriented towards educational goals relating to the location and synthesis of information, despite the occasional 'research project' students are given. We continue to test students on predetermined content. We really do not know what to do with a vast quantity of information and we cannot think of useful questions. Furthermore, we do not know how to manage the experience. How can students have equal opportunities to make inquiries of the information sources?

The need for information accessing skills is going to escalate so much in society that the educational community will agree on a need for systematic experiences throughout the school. Locations with few local resources will be able to access the same range of information as more advantaged areas, which could be a real breakthrough in attempts to equalize opportunity in education. So I predict that there will be social pressure for development of these sorts of experiences in schools. Teachers who only refer to textbooks or to their own accumulated information on a topic will gradually be outnumbered by teachers with skills to utilize more, and more varied, resources. This does not, of course, imply that teaching and learning will necessarily be better—having access to information is only a first step. Different approaches in teacher training and in student assessment criteria will have to occur, and classroom management strategies will still have to be developed and modelled. However, these are variables that can be manipulated. Teacher disposition towards this sort of experience may be less easy to manipulate, despite training activities, because the conceptual and management challenges will be significant.

PROCESSING COMPLICATED DATA

IT tools can be used to perform tedious or complicated manipulations that would otherwise limit student participation in various educational experiences. For example, in the science classroom, data-capturing peripherals can be readily affixed to even simple computers to allow the capture and manipulation of types of data that students might not otherwise be able to experiment with. Work in this area of the application of microcomputer-based laboratories (MBLs) is extremely promising and will enable a real change in the science laboratory situation in schools (see Nachmias and Linn, 1987). More extensive and realistic manipulation of variables can take place, with more time available for student speculation about hypotheses, as less time has to be spent on mechanical tasks such as recording data.

In the senior mathematics classroom, IT devices can also be used as enabling tools for learning situations that might not otherwise occur. Monte Carlo simulations to develop concepts of inferential statistics, the use of graphing tools to investigate characteristics of complex functional expressions, the use of spreadsheets to develop skills in projecting and manipulating trends in quantitative data, all relate to important aspects of mathematics which are not often included in school syllabuses.

Qualitative data can also be complicated. We have already discussed the difficulties inherent in locating, synthesizing and projecting trends from information in large data bases and how technology can be used to overcome these difficulties in the social science classroom. In mother-tongue classes, the contribution to the development of the writing process through the electronic manipulation of text has been extensively discussed and researched.

All these promising new educational systems involving IT share one frustrating characteristic—they are still relatively little used in practice. National surveys in the United States and Canada, for example, yield almost identical data on this point (Martinez and Mead, 1988; Kass et al., 1987). Despite the nearly universal presence of computers in secondary schools and the exposure of most students in these countries to some sort of introductory computer-use course, less than 14 per cent of the 27,000 students in the surveys had ever made use of computers in their science and social science courses, and less than 22 per cent in their mathematics courses. Word processing is also little used (only 16 per cent of the respondents indicated they had ever used it) although more than half of the respondents had training in such techniques in their introductory IT courses.

Why is realization proceeding so slowly? It is convenient, and true to a certain point, to say that there are inadequate hardware, software and teacher training. But even with reasonable provisions of these support resources, such as in North America, computer use in schools is dominated by information-technology-specific courses rather than by integration of information technology in a way that creates new educational situations in other subject areas. I think the problems here are more subtle, and more difficult. We have not yet succeeded in demonstrating to teachers that there are real educational needs that IT tools can help them address more effectively than they could using other tools. It is my view that IT use in conjunction with regular instruction is still too often perceived as more of a frill than an important opportunity. The management and organizational aspects of integrating IT tools into instructional delivery outside of informatics courses also create a major constraint on their use. Such constraints are more serious than may be acknowledged and their manipulation is a particularly important aspect of improving the realization of the potential of informatics to create new educational situations (see Collis, 1988*b*).

PROVIDING MICRO-WORLDS FOR EXPLORATION

The term 'micro-world' came to widespread attention in the context of Logo experiences,[9] but it can be used more broadly to describe any situation where IT allows the student to explore and manipulate some kind of bounded universe. The use of simulation programs can also fit this definition. In a sense, working with a tool such as a spreadsheet can also be seen as a microworld experience. Besides the relevance they may have with respect to certain learning domains, an additional goal of many microworld explorations is to enhance students' higher-level thinking skills. This kind of enhancement is sometimes predicted in terms of gains in problem solving skills, or planning skills, or in terms of some other aspect of cognitive activity.

Much research has been done to investigate various types of learning gains that might be associated with micro-world explorations. This has resulted in a deeper appreciation of the complexity of skill development in these sorts of environments. Beyond this, the outcomes are not clear.[10] Many factors influence any results that do occur, results are inconsistent across studies, and management and organization of the experiences is challenging, often enough to prevent the experiences from being used for more than a limited time. Some generalizations, however, are emerging, notably that student exploration with micro-worlds results in more demonstrable learning gains when it is guided by the teacher and integrated into a complete instructional experience than when the student works independently; and that most students seem to lack the motivation or vision to explore micro-world environments to any depth without effective teacher guidance.

How do these observations relate to critical, manipulable variables? The point about teacher guidance gives us a clear message: focus on helping the teacher visualize, prepare and manage educational activities that include microworld exploration but that guide students toward certain goals. This does not have to constrain the emergence of other outcomes from such explorations. The opinion about student motivation is more controversial. I believe that, despite an ongoing theme in educational theory relating to the idea of students being architects of their own learning if they are only given the appropriate tools, most students are not going to be motivated to deal with strenuous intellectual challenges or be able to extract principles and concepts from their explorations. This, in fact, may be a critical variable that is limited in its manipulability. If the new educational situations created by information technology assume a new type of learner and teacher, then there may be continual frustrations in realizing the potential of these situations, at least in the foreseeable future.

Informatics as a new curriculum situation

In contrast to the limited realization of the potential of IT in terms of creating new educational situations in traditional curriculum areas, there is no doubt that IT has been associated with one new type of educational situation which has rapidly become widespread around the world. This is a course, or at least a compulsory unit of instruction, in informatics (called by various names in different places). In many countries, this type of experience has been mandated nationally; in countries where this has not happened it is none the less common to find some kind of local initiative. These experiences are common at both the introductory and specialized level. Frequently they include programming, though the introductory courses now usually include some experiences with software applications. The rapid acceptance around the world of a new content area in schools, one which requires relatively heavy capital investment and one for which there is no installed base of trained teachers, is remarkable.

The initial motivation for many of the courses was better job prospects in a technologically dominated society. Careful analyses of projected employment needs and the contribution of the typical school informatics course to employability requirements has made this motivation for informatics courses less credible (see Levin and Rumberger, 1985). The contribution of such courses to subsequent success in profession training with respect to informatics is also hard to verify. Because of the variation in the content and quality of secondary school informatics experiences, many universities also begin computer science instruction in a way that does not require the student to have had preliminary courses. The uncertain contribution of these courses to the development of better thinking skills can be seen from an examination of the extensive research in this area (Blume, 1984; Land and Turner, 1985).

There is not even much data to help evaluate what students are actually learning in school-level informatics courses. Sometimes syllabuses are compared for subsequent analysis, but student learning is often not synthesized from place to place or country to country. The survey by Martinez and Mead (1988) of over 24,000 American students determined that the majority (67 per cent) had some kind of informatics study in school, virtually all came from schools with computer resources, and most had 'some familiarity with computers, for example, they can identify a keyboard, disk drive, and printer . . . but with the exception of word processing, only a small fraction were able to answer questions about the most important computer applications' (Martinez and Mead, 1988, p. 29).

Through the appearance of new courses in school, IT has definitely caused a change in the educational situation, certainly in secondary schools, but there is little reason to think that the money and effort that have gone into the establishment and maintenance of many of these courses are paying off. I would like to go even further and call for a cost-benefit assessment of such courses; relative both to alternative uses of the same amount of money, perhaps for the integration of various types of computer use into curriculum-related instruction (for example, telecommunications for information access and science data-capturing peripherals for experimentation enhancement); or relative to other, non-IT uses. The impact of informatics courses on the overall educational situation in schools may be both too much and too little: too much if the majority of computer-related resources is focused on these courses, and too little if the uses of IT are not reinforced by application in 'real' situations throughout the school. It has been argued that a reasonable level of 'informatics competency' can be developed through judicious use of IT tools in various appropriate ways in the context of regular curriculum instruction (Lockheed and Mandinach, 1986; Collis, 1988*a*). I am not suggesting that an informatics awareness course and some sort of systematic instruction in IT tool usage skills be removed from school experiences. On the contrary, I am suggesting increased awareness, but through more realistic and cyclical use of IT tools than typically happens at present when, for many students, a single exposure in an informatics course is all the contact they have with school IT resources.

Changes in the organization of human interaction during learning experiences

STUDENT-STUDENT INTERACTION

Occasionally a rather grim image is projected relative to some futuristic learning situation. In this image, a small child sits alone with a computer, isolated from human interaction. Another image is that of the computer-obsessed student, forsaking normal human interaction in order to work with his computer. Although some examples of the latter do occur, IT use is more generally becoming associated with some encouraging trends in the social organization of learning. Although the majority of software packages are designed around the assumption of a single user interacting for some period of time with a computer (an assumption that shows how many software designers fail to anticipate the context that will constrain the use of their packages in the real-world classroom), the reality, of a limited number of machines in the school environment compared to the number of students wanting to use the machines, has fostered the development of group work, or at least paired-student work, with IT tools.

Sometimes the group organization is deliberate rather than a response to equipment constraints. Some senior-level informatics courses are trying to mirror real-world experiences in software development by structuring student experiences and assignments around group work. Some telecommunications experiences are developed around the idea of group interaction for the construction of responses to messages. The idea of writing as a social activity, made possible by word-processing and desk-top publishing facilities, is also gaining recognition. Group work in the context of learning programming has been perhaps the most extensively researched aspect relating to social organization of IT-related experiences and the results have been positive (see Webb, 1985). Student co-operation during the use of simulation software is frequently encouraged and has been shown to be associated with better learning than independent interaction with the same software. (For an example, see Johnson et al., 1986.)

Group work obviously existed before IT, so I do not think we can say that IT 'creates' any new educational situation in terms of student-student social interaction. However, it does seem that certain types of IT naturally promote student-student interaction in ways which would probably not occur with traditional resources if the teacher allows it. Given this promising research, why is student-student interaction not encouraged more as part of IT-related experiences? One reason relates to software; as mentioned earlier, most software is built around a single-user model. Two students working together, for example, often have to be called by a common name when getting feedback from the program, and prompting is virtually never given with the purpose of encouraging students to take turns at responding. Also, most software is still drill-and-practice in approach, an unnatural environment for multiple users unless both are at a similar ability level.

Another reason relates to the difficulty of organizing group work in the classroom. If students are not used to group work, some may dominate the group or the group may not be comfortable or efficient at apportioning responsibility. Assessing group work is also difficult in terms of the eventual need to assign individual marks to students. Finally, group work may be outside the teacher's range of preferred classroom organizations; certainly group work is associated with a level of movement and noise in the classroom which is not always kept under control, nor do all students work productively during group work sessions. Thus teacher-comfort relative to control and management in the classroom is a critical constraint on the types of IT experiences that will occur in classrooms. I am not sure how successfully we can manipulate this.

TEACHER-STUDENT INTERACTION

It is frequently stated that IT tools create the possibility of new or newly emphasized forms of student-teacher interaction. One of the most frequent comments is that IT gives students tools to 'be in control of' their own learning, and that therefore the teacher serves as a reference person, relative to strategies for locating information, or a facilitator, relative to helping students realize their own decisions about learning (see Solomon, 1986). A less radical view sees IT, usually in the context of computer-managed drill programs, keeping track of 'routine' student activity in some sort of predictable situation, such as drill work in arithmetic, freeing the teacher to interact more closely with students over more stimulating or demanding topics.

The great majority of students cannot or do not wish to organize their own learning activities in a far-sighted way on more than a short-term basis. Mathematics, science, history or chemistry, for example, as rich and dense conceptual areas, cannot be effectively anticipated by students so that they can choose appropriate learning directions over more than a short time, even assuming they are self-motivated. I am not suggesting that students not be given some control over their learning options; however, I believe in general that students are unable to create the options in order to choose among them unless they already have some sophistication in the content area and in monitoring their own behaviour. We have so much evidence about the importance of the teacher in appropriately sequencing instruction for students and of the importance of sequence in many curriculum areas, that I think it is more romantic, and undesirable, than realistic to plan for a radical change in the nature of teacher-student interactions.

To date, IT use in the classroom has typically been associated with more work for teachers, rather than with more time for higher-level activities (OTA, 1988). It also appears that much of the extra demands on teachers relates to low-level organizational matters associated with technological management, rather than on enriched higher-level contacts with students. Another issue is that teachers frequently lack the time to interpret information on student activity collected by computer-management systems during student use of drill programs. The fact that these printouts often give little information beyond 'number tried' and 'number correct' adds to the unlikelihood that any meaningful management of learning is being done for the teacher.

I believe there is at least one aspect of student-teacher interaction which IT experiences can promote which is of potentially high significance. The teacher as an IT user, especially as a new IT user, will inevitably be faced with challenges in the classroom, ranging from the trivial trouble-shooting of aberrant equipment to much more challenging problems involved with understanding facets of a new software package or hardware system. I believe that students often learn from observing the modelling that they see in their teachers' behaviour. Students can watch their teachers as learners, relative to IT use, and see them as learners who can sometimes be taught by the students themselves. There can be a palpable change in the relationship between teacher and students when students can share a legitimate problem-solving experience with the teacher, not just react to one contrived for them by the teacher. I believe the teacher can set a particularly strong example of viewing problems not as failure experiences but as interesting challenges for which a variety of lines of investigation may be appropriate. A tendency towards more and more user-friendly software may, ironically, reduce the likelihood of this sort of shared learning experience. Also, teachers need to be willing to grapple with their own lack of knowledge in view of their students and be comfortable with letting students see them as sometimes unsuccessful. This sort of willingness may not be easy to develop.

Changes in the teacher's role

The most common preparation pattern for many teachers seems to be textbook-related. Teachers do make their own instructional materials, generally in printed form though often in the form of extra visual aids. Many software packages are equipped with facilities through which teachers can modify data sets in the software and thus personalize computer-related learning experiences for their students. The extreme form of this relates to complete authoring environments for teachers, where the teachers can ostensibly design and create their own software.

How much is this potential for software development or modification being realized by teachers? Good data on this is scarce, but my impression is: very little. If this perception is accurate, what factors are impeding the realization? One response is to look for more sophisticated possibilities; perhaps teachers are not bothering to spend time adapting software if in fact they can only make highly constrained changes? Perhaps tools that allow teachers to create lesson materials through assessing multimedia data bases will make a critical difference? Another response is to search for easier-to-use authoring tools, with improvements in user-friendly interfaces.

My prediction is that efforts such as these will not result in increased realization of authoring or adaptation potential in any widespread way, unless other changes occur first. These are changes that relate to the much more fundamental issue of teachers coming to believe that IT-related use relative to important educational problems can make a significant contribution. Until this commitment is more widespread, there will be little increase in willingness to spend time on modification of materials for IT use.

In summary then, I differ from many in that I do not predict IT use in educational settings will create a fundamentally new role for the teacher. I believe the things that are important now about the process of being a good teacher will remain just as important. The teacher will be faced with a wider spectrum of things to know about and do, and a wider range of creative opportunities because of IT. But in general, the important aspects of being a good teacher—planning, assessing, reinforcing, motivating, interpreting, interacting, caring—will remain as important as ever.

Changes in physical organization within schools

TRANSFORMATION OF THE LEARNING ENVIRONMENT

IT has already made a visible change in the physical organization of at least one room in many schools around the world. Computer laboratories are no longer uncommon in many countries, and computer rooms can also be found in at least some elementary schools. In many schools, computers are locally networked. Stand-alone computers are also relatively common in schools, though the laboratory is seen as highly desirable for informatics instruction.

Although this rapid introduction of costly new equipment along with the challenge of finding a room in the school that can be converted into a computer laboratory is significant in itself, there are many ways that the physical orientation of the school could be further changed because of IT. In many secondary schools, there is more than one computer laboratory. Often an additional laboratory is dedicated to instruction related to data processing and office skills. Laboratories for computer-aided design/computer-aided manufacturing (CAD/CAM) installations or for other technical training situations are also becoming widespread in more affluent societies. The idea of having smaller clusters of computers, particularly for the word-processing requirements of students, is beginning to be realized. Some school libraries are being reorganized around various applications of IT, ranging from circulation and card-catalogue use to on-line linkages with external information sources.

Predictions about the potential of changes in the physical organization of the school can involve even more than the appearance of new rooms of equipment. As the library situation suggests, there is considerable potential to reorganize the working environment of the student. In some well-networked schools, students can log on to the computer system at any one of many terminals located throughout the school and access their own work.[11] However, these networks still often cause technical difficulties and they require ongoing technical support.

Some see the potential extension of local area networks to be a situation where all students have their own portable computer and can access the central resources of the school through the workplace of their choice. Instead of organizing the school around the notion of classrooms with desks aligned to face the teacher and the blackboard, both centrally positioned at the front of the room, the school building may radically change in its interior. Access to a printer will be more critical than proximity to a blackboard. Since teachers, in this sort of environment, will be 'resource guides' more than 'front-of-class lecturers', the traditional classroom may be more and more reorganized to look like a resource centre.

REFLECTIONS ON CURRENT REALIZATION RELATIVE TO LABORATORIES

For certain teaching situations the computer laboratory is both convenient and desirable, such as for teaching groups of informatics students. However, there are a number of problems associated with the computer laboratory organization.

Computer laboratories often become bottlenecks to access to school computers for both staff and students. Because informatics is popular, and sometimes compulsory, the courses themselves place heavy demands on the scheduling of computer laboratories. Consequently, it can become difficult for non-informatics teachers or students to have access to the computers. As a result, a pattern can emerge in which the few informatics teachers become virtually the only users of such resources and the computer laboratories are seen as their domain. This has an impact on both instructional integration and atmosphere.

It is, of course, possible to reduce such domination of the computer laboratory through centralized scheduling or more laboratories. However, a potentially more serious problem remains. For the informatics teachers who wish on occasion to integrate some type of computer-use experience into their larger instructional plans, the physical process of relocating students into the lab is often disruptive to lesson flow. This is especially so if the experience is of relatively short duration, although still of instructional value, as may be the case with the desire to access an on-line informational data base or to demonstrate a certain functional relationship in mathematics. Sometimes, for instructional integration, the use of computers in a central laboratory is impossible, as may be the case in wanting to capture some data during chemistry experiments.

With younger students in elementary school situations, where a laboratory may have a smaller number of computers, the teacher faces additional problems. How can some students be in the laboratory with the computers while others are in the classroom? How can the teacher work with both groups of students at the same time? Is the solution to allow the students in the computer room go unsupervised, under the assumption that they can work independently with the computers? Probably this in turn assumes that they will be doing some sort of computer work, such as drill, which can (not should) be done in isolation. However, both conceptual and technical difficulties still occur in leaving young children alone in a computer room without support. Schools thus need at least an aid in the computer room to deal with technical questions, but this does not compensate for the missed opportunities for interaction between teacher and students. To maximize instructional integration of computer use, it would be desirable to have a number of computer laboratories, extra teachers, and stand-alone computers for specific classroom uses. Realizing this kind of potential requires more money than is normally available to school authorities, unless a 'special project' is mounted with substantial outside support.

Another consequence of the informatics domination of school computer facilities is that not only a subset, but also a certain type, of students and teachers often become associated with computer laboratories, in secondary schools at least. In many places, this group is characterized by male students taking (or expecting to take) higher-level mathematics courses. The strong correlation between this and the fact that fewer females than males make use of school computers or take elective informatics courses does not of course imply causation, but it does support the observation that in many places the computer laboratory develops a characteristic atmosphere which does not seem to encourage usage for certain groups of teachers and students. One response to this is to encourage more widespread instructional integration, but as we noted above, until resource provisions are considerably larger, laboratory placement of computers can thwart attempts at this type of organization.

I am confident that we shall see more and more computer laboratories in schools. Despite their problems, they make a more natural management unit than is the case with computers dispersed throughout the school and are the most logical teaching environment for informatics instruction and other specialist courses, such as office skills training. Bottleneck problems will be addressed by obtaining more computers and setting up more labs, even though this may not do what is needed for problems of instructional integration in the regular classroom environment. Local area networks (LANs) will also continue to grow in popularity, not so much for pedagogical reasons but because of the problems of having multiple copies of software to service multiple machines in a school and of having access to printers. With the rapid spread of technological advances in society, I think it is quite likely that this sort of physical change will continue to occur in schools.

Changes in the macro-organization of schools

There are two basic frameworks for potential changes in the macro-organization of schooling, given large-scale IT resources. One framework is that the school can be brought to students who would otherwise go without. We can see examples of this in the use of computers and telecommunications, as well as other technologies, for the delivery of instruction to students living in remote areas in Australia and Canada, among other places. Distance education augmented by IT allows interaction and multi-media provision of resources in ways not possible with traditional print- and mail-based distance education. Courses requiring specialist teachers can be delivered to students in small, rural schools. The potential impact of this on geographical inequities in educational opportunities is highly significant.

The second framework relates not to bringing the school to the student, but to giving the student access to enough resources so that the school is no longer necessary. A number of predictions about the potential of IT to facilitate this sort of 'liberating' self-sufficiency have been made. Some are less radical in that they see the student still going, on occasion, to a school for some sort of interaction with a teacher or other students; others predict the dissolution of schools, and of the teaching profession, as a natural outcome of IT realization.

I predict that IT-mediated distance education, delivering educational opportunities to students for whom the opportunities would otherwise not be possible, is an important growth area for IT. Realization of potential to some extent will occur because the need is strong and clear. Technical problems abound, and a costly infrastructure is needed to handle this sort of realization. Portability of materials must also be considered, from the technical as well as from a cultural perspective. This involves not only the student's community-related culture, but also the pedagogical culture with which the student is comfortable. We have enough experience to know that all of these are significant constraints on realization, but constraints which can be dealt with when the need and will for IT-supported compensatory education is strong.

On the other hand, I do not predict a 'fading away' of the school. I believe the need for school organization, for teachers as instructional leaders not just reference guides, and for human-to-human support, interaction and motivation will continue. Given the many constraints on realization, I am confident that many elements of traditional school organization will, and should, remain regardless of IT's potential. ■

Notes

1. I define 'realization' as the use of a resource in 'widespread enough' fashion so that its benefits are being experienced by a variety of learners in naturally occurring situations (as opposed to experimental or special projects). Its essence is, stated more simply, 'To what extent are the things we predict could happen, actually happening?'
2. Martinak et al. (1987), for example, had only limited success (30 per cent of errors matched) in developing software that could match student errors with an accurate diagnosis of student misconception, in order to provide an appropriate individualized response to the students.
3. Among the major realizations we have acquired are that the process is enormously complex and that it varies from individual to individual as well as within the individual, depending on situational variables.
4. I recognize that it may be the experiences we are acquiring with respect to our attempts at individualized instruction with computers that will directly contribute to this better understanding.
5. Information about the International Symposium for Telecommunications in Education can be obtained from Mr B. Feinstein, Ministry of Education, Rehovat, Israel.
6. One of the most ambitious of these projects is Kidnet, co-sponsored by the National Geographic Society in the United States and involving over 200 schools in six countries.
7. See Martinez and Mead (1988) and Kass et al. (1987) for results of two national surveys in North America.
8. Riedl (1986) calculated the cost of forty students and three teachers making extensive use of an on-line informational service from their school in Alaska to be $320 for an entire school year.
9. Papert (1980), of course, brought the word and idea to broad public attention.
10. See Govier (1988) for a summary of Logo research in the United Kingdom.
11. The Canadian province of Ontario has extensive experience with networked schools.

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