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ABSTRACT

This paper examines the use of computers and communication technology for the storage, retrieval, dissemination, creation, analysis, and transformation of information. Examples are provided of the use of compact disks for the storage and retrieval of counselling and research information. To demonstrate the role of information technology in information dissemination, applications of computer conferencing for enhancing the tutoring and learning process at the British Open University are reviewed, and the potential of the French Teletel system for educational uses is discussed. Also considered are applications of computer technology in the creation of information through word processing, desktop publishing, and electronic publishing. Electronic spreadsheets, computer simulations, and micro-worlds are then discussed as tools for information analysis and information transformation. It is noted that two of the major obstacles limiting the use of information technology are shortage of qualified and experienced staff and hardware and software obsolescence, and remedies are suggested. Four rationales for information technology in education--social, vocational, pedagogic, and catalytic--are outlined. The paper concludes with a review of the use of information technology at the Dundee Institute of Technology. (5 references) (GL)

TOWARDS 2000: INFORMATICS IN EDUCATION

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Setting the Scene

I feel honoured to be invited to celebrate with you the Centenary of the Dundee Institute of Technology. This is yet another marker in the long and distinguished tradition of Scottish education. If one of the founders of this institution were to walk around here today, doubtless he or she would be astonished at the progress -- and intrigued by all that the Educational Services Board provides for staff and students. But, rightly, we are here tonight to look to the future while celebrating the past: 'Towards 2000: informatics in education' is the title for this evening.

Does this title arouse varying responses? Let's start with the pessimists, who may ask will there be any informatics in education by that date? The end of the century is such a short time off, money is very scarce and education is so slow to change. Next, liberal sceptics may question what beneficial impact, if any, informatics can have on education, that essentially human-oriented process. Many social realists are well aware of how much informatics we already have, and some worry about the damage it may do to education. Technological utopians think we should have far more, because they perceive great benefits for students and staff. Personally, I'm a cautious optimist on this matter: I believe we should exploit the technology for education, and not let it exploit us.

'Informatics' is short-hand for what our government prefers to call information technology, a combination of computers and communication technology that is particularly useful for storing, retrieving and disseminating information. To those three functions, I want to add those of creating, analysing and transforming information. In this Institute, and in secondary and tertiary education worldwide, computers are being used by staff and students to create, analyse and transform information, processes at the heart of education.

This evening I shall use most of my time to give you 'cutting edge' examples from education of each of these functions. Then I shall speak briefly about some problems we have to face, and the underlying rationales for using informatics in education. Lastly, I want to make a few remarks about informatics here in the Dundee Institute of Technology.

Storage and retrieval of counselling and research information

For counselling. Here is a compact disk. You could easily mistake it for the kind used for playing Mozart's piano concertos with crystal clarity and fidelity. In fact it is a CD-ROM, (Compact Disk Read Only Memory) for the Educational Counselling and Credit Transfer Information Service (ECCTIS), developed by my University for the Department of Education and Science and used by many higher education institutions in the United Kingdom. It is a fine example of information storage and retrieval being used to benefit students. The disk holds details of 70,000 courses offered in the United Kingdom. Yes, you say, we have come across directories like that before, admittedly rather heavy ones. The difference is not simply the size. This database can be searched in many different ways: all courses in biology, all biology courses focussed on molecular biology, molecular biology courses only in Scottish universities, and so on and so on. Students and their counsellors have immediate access to the information they need. Of course, besides the disk, the service is available 24 hours a day on-line, through an electronic gateway which I am sure can be accessed from this Institute. In 1987, there were over 110, 000 on-line enquiries.
Students can even order prospectuses if they want to, and each year from mid-August to late September ECCTIS carries daily updated information about higher education courses with vacancies. This is a superb addition to what UCCA and PCAS started.

For research: Last week, I wanted to know about the latest published research and reports on computers in schools in developing countries. The old way to do this was to go to the library and

look up various indexes. This would lead you to a range of journals and possibly other publications, such *Dissertation Abstracts International*. If you were lucky, some of these would be in your library, but most would be elsewhere. After a long and expensive search, you would be left with the feeling that if only you had looked longer, you would have found something more, perhaps a vital publication.

Informatics has changed all that. Now I go to the library and sit down for half an hour with one of my librarian friends who knows how to search the computerised databases, such as ERIC (Educational Resources Information Centers). I could probably do it myself, but not as well. He helps me to select the descriptors, and when we know what we want, he asks me whether I need the most recent information only. If so, he sends the signal via telephone and satellite to the computers in California. In no time at all, we know how many publications are available, and we probably request the bibliographic details, at a cost of a couple of dollars. We decide from these details whether we want the abstracts, which are cheaper if you order them by airmail, but you can have them downloaded onto the library computer. Or you can order the full document, on microfiche or as hard copy. If I were interested in work published in the period 1980-86, my friendly librarian would not bother to connect his computer to the ones in California. Instead, he would use a compact disk just like the one for ECCTIS. He would complete in minutes a search of hundreds of thousands of items. What a marvellous device and what a marvellously efficient way of doing a search! Compare it with searching this single volume for just one month for ERIC.

Dissemination for tutoring, learning and homework help

For tutoring and learning. The Open University is a pioneer of computer conferencing in this country. Last year, for the first time, more than 1300 students studying a course on information technology, had modems through which they could link their own computers at home to those of other students and tutors, via telephone lines and the University's big computers. They were encouraged to join computer conferences of two types, open and closed. Open ones could be joined by anyone on the course. Closed ones were limited, say, to members of a tutorial group. Students receive an Electronic Campus map for the course. As a student, you enter the campus, metaphorically speaking, and have access to all the buildings, including the Student Union ('like a bar that's always open'), the Tutorial Building, and so on.

A computer conference is different from a telephone conference because the conferring is asynchronous: that is to say, you don't have to be on the line at the same time as the others. Imagine you want to start an open computer conference on a knotty problem you had found in part of the course. You enter the system and put up your conference title: Using Information Technology in Cheque Clearing for Banks. You type in your version of the problem, and ask for help or comments. Then you go away and wait. In the computer conferencing system there are browsers and lurkers. Browsers read and respond, lurkers read without contributing. Two days later, maybe, you look to see what the browsers have entered for your conference. To your delight, Hamish Macdonald, who works in Edinburgh for the Royal Bank of Scotland, explains it all perfectly, or so it seems to you. But beneath his entry is one from Gwyneth Davies, a student in Cardiff, who disagrees slightly with Hamish. And below that is a friendly comment from Richard O'Brien in Belfast, a tutor who actually designed an IT system for one of the banks. Richard explains why Hamish and Gwyneth apparently disagree, but are both right. Meantime, goodness knows how many lurkers have lurked around, learning from the debate! Computer conferencing seems like a winner for education in the year 2000, as the technology gets cheaper in real terms.

For getting homework help. For a second example of informatics being used for dissemination we go to France. There is some educational use of the French Teletel system, which is something like Prestel but much more widespread. It has placed a computer terminal in several million homes, connected by telephone line to large central computers. Originally it was intended to provide an electronic telephone directory to replace the paper ones and operator enquiry services. 1987 figures showed 20 million 'directory' calls a month. But let somebody who provides an educational service speak about it for a minute. Here is Cecile, on video.

This may seem like quite a trivial educational application of informatics. Sadly, Cecile doesn't sound much like a real educational provider, does she? The main service demanded by consumers in this system is not education, not even banking, but telephone directory information. But we

should certainly bear in mind this 'wiring of a nation' as an educational possibility in our country too.

Creation of the printed word

Informatics is valuable in education for creating information, too. In case you are having difficulty with that word 'creation', I am using it in a broad sense, the making of something that did not exist before. Television or video production, including the use of computerised graphics, seems to me the most obvious example, but as I know little about that process, let me choose word-processing, desk-top publishing and electronic publishing instead.

For word-processing. It is now commonplace for university staff to use word-processors in their writing. Indeed, at the Open University, where print is the dominant teaching medium, typewriters have almost disappeared. I need hardly tell you how useful we find word-processors: writing our courses involves several drafts of the teaching material, to be considered by the course team and its external assessor, often to be tested by a group of quasi-students, and always to be edited by professional editors. The writing consists of a certain amount of compilation from other sources, as well as original authorship. Like all academic writing, our sources must be properly referenced. All of this work benefits enormously from word-processing.

For desk-top publishing. Desk-top publishing goes a stage further, and has excited the educational world with visions of cheap, small-scale publication of books and other material prepared entirely by the author. Speaking as an author myself, I do like to have some control over the words appearing on the page. With a desk-top publishing program in my computer, I can control almost everything, in detail: typeface, size, layout and so on. I can see on the screen the pages exactly as they will appear in the printed document, which will be indistinguishable from one from the printers, *provided* I have acquired all the necessary skills in using the program. Frankly, I don't have all these skills, and I'm not sure I want to acquire them, marvellously versatile though the programs may be. There are still advantages in some division of labour, and I would prefer to hand over my word-processed document to a desk-top publishing specialist, if that is the route by which my writing is to be published.

For electronic publishing. Electronic publishing shortens, remarkably, the path from author to reader, you could say. At the Open University, it starts with word-processing in the usual way, except that we use standard formats built into the software. Authors hand over their disks to editors, who send the edited text through to computers which can also handle the computer-generated drawings created by our graphic designers and illustrators, plus the scanned-in photographs. Again, the software plays a major role in ensuring that the publications will meet OU standards of house style. The final product is film or bromide suitable for direct use by printers. The University does not print its own texts, because commercial printers can do this much more economically.

By the year 2000, the Open University will probably be sending out much more of its teaching materials on disk, for reading on screens. Already, about 12,000 of our undergraduates have computers for their courses this year. Because we use electronic publishing techniques, we shall be well-placed to make that move. Maybe students will have flat hand-held screens by then, suitable for use in the train and so on, as convenient as a book and much more versatile.

Analysis using a spreadsheet

Under this heading, let me choose the spreadsheet, a general purpose tool in the same league as word-processing. On the screen, a spreadsheet looks like a grid or matrix. It spreads 'off the screen', so to speak, in that you can move around within it, left or right, up or down, within the range provided. One I use, called Excel, has about 250 columns, and over 1600 rows. But you only use what you need -- and what the memory of your computer can cope with. You can label each column and row. You can enter data in each cell. And you can specify the mathematical relationships between cells or combinations or cells. A simple example would be where you wanted the total for all cells in the column labelled 'Postgraduates'. A more complex case might require a formula, describing how changing the values in certain cells would impact on values in other cells.

Spreadsheets are invaluable to students and staff alike. Students can use them in their project work, for example, to prepare tables of data and to carry out analyses. Academic staff can use them in preparing lectures and research papers. Administrative staff find them very effective when they want to analyse and present financial and planning data.

Transformation in simulations and microworlds

Information technology comes into play in the most remarkable way, perhaps, in transforming information. Computers can handle large quantities of data with such speed that you can create simulations and micro-worlds in which students' inputs cause almost instantaneous transformations. Such interaction provides for poweful teaching.

For simulations. The best known example of simulation is in the training of airline pilots. We all know that the aircraft simulators are now very highly developed, so that the pilots find the simulation utterly convincing. Not only do the aircraft's instruments behave as in flight. The whole 'cabin' moves, the view through the widescreen shifts appropriately and the pilots hear the noises they would expect to hear. One British Airways 747 pilot jokingly said to me that now the designers were trying to make the planes more like the simulators, and there is some truth in that, because simulators can simulate dangerous situations no plane would normally experience, but should be capable of doing so and surviving. Training the pilots receive is absolutely first-rate (see Hawkridge, Newton and Hall, 1988, for further details).

But simulation is available as a very convincing teaching technique at very much lower cost. Good quality simulations of scientific processes, for example, are widely available for microcomputers used in our schools.

For micro-worlds. Micro-worlds are a particular kind of simulation, for educational purposes. Perhaps the best-known example is LOGO, the simple yet powerful programming language developed by Seymour Papert (1980) so that children could control their own micro-worlds. He takes the view that children can learn a great deal by doing so. I'm going to use eight precious minutes to show you an example on video, which we may want to discuss later this evening.

Some of my colleagues (Scanlon and Smith, 1988) have been developing micro-worlds to help children learn difficult concepts in physics. Children tend to develop informal theories about natural phenomena such as the weight of air, the nature of vacuums and what happens when substances dissolve. What can computers do about this? Computers can help children to make explicit their implicit reasoning. They can enable children to visualise the consequences of their reasoning, in ways which others can discuss with them. They can provide pictorial representations and dynamic displays of models of phenomena, which can form useful bridging analogies. And computers can log data and display the results quickly, so that children can perceive how variables are related: change this and you change that, and so on. In other words, microworlds encourage children to express their own ideas and see what happens. They can 'stand back' and inspect their own thinking. (This list is drawn from a 1988 proposal to the Economic and Social Research Council by my colleagues and others from Leeds and Glasgow Universities.)

Probably the most exciting micro-world under development at the Open University is Shopping-on-Mars, a non-violent adventure game aimed at children aged 8-12 who are learning arithmetic (Hennessy, 1987; O'Shea, O'Malley and Scanlon, 1988). It helps them to realise that different kinds of problems need different kinds of calculation and encourages them to use informal methods of calculation. Its developers offer the following description:

> The key theme of Shopping-on-Mars is a three-way interaction between a computer -- acting as a shopkeeper-checker-diagnostician -- and two or more children -- acting as customers or checkers. Two players land on Mars with a rocket with no remaining fuel. They cooperate in a series of purchasing tasks, with the aim of obtaining enough fuel to return to Earth. They navigate the Mars landscape in search of the fuel shop, but their progress is thwarted by obstacles which can be overcome by buying articles in nearby shops. As customers, the children take turns in buying items and are encouraged to check their change. The computer is shopkeeper and controls the level of difficulty. Computer-controlled Martians, helpful and inquisitive creatures, try to

intervene intelligently encouraging use of efficient calculation tools and informal methods of calculation -- they all the common methods and associated errors. They ask about children's invented methods and can cope with a wide range of observed difficulties.

Problems and remedies

So is the informatics Utopia with us already in education? Of course not, and perhaps it never will be. We face appalling problems in the years to 2000 AD. I choose two of the most important for brief discussion tonight: staffing and obsolescence.

Staffing problems. The first is the shortage of qualified and experienced technical staff. Without them, progress will be slowed and mistakes will be made. Educational institutions, because of their relatively low pay-scales, are finding it more and more difficult to recruit and retain staff in the field of informatics. Overall, the nation is not training enough anyway. We are about 30,000 people short now, and that figure is expected to rise to 100,000 by 1993, according to a report in *The Guardian* last week. Optimistic predictions that more user-friendly computers and less need for programming will drastically reduce the need for such staff are not likely to come true by the year 2000, as far as I can tell.

Obsolescence. The second is the rapid obsolescence of hardware and software. It is safe to prophesy that, by the year 2000, about half the staff of Scottish institutions like this one will still be in post. In that same year, very few indeed of today's computers will still be operating, and scarcely any of today's software will be in use. In my own University, we are obliged to change the hardware and software standard for students every six years or so, at immense cost, though with benefits too.

The remedy for the staffing problem is not simply money, more money, but more would help. It does seem extraordinary that a government committed to information technology and to economic development should hamper the use of informatics in education by starving us of funds. It is even more amazing that such a government has failed to give a lead that would bring more women into informatics, not least in education. By creating an ethos of 'industry and business first', the government has also ensured that jobs in informatics in education are perceived as less attractive than they should be.

The remedy for obsolescence is indeed more money: there is no other. Our society is in the grip of a form of technological determinism, which says we must have the technology updated to survive. Fifty years ago J.A. Schumpeter (1939), an American economist, wrote about the 'creative gales of destruction' which he thought had swept the capitalist nations, producing large-scale and long-term change. He knew nothing of the information technology revolution, but it is surely a creative gale of destruction, not least in Dundee, which has borne the brunt of some of the strongest blasts and survived through changing its industrial base. Under such conditions, educational institutions must respond to the needs of the society in which they have their being. If informatics is the new basis for much of our economic life, informatics must be in education. But that sounds too simplistic -- and it is. What for?

Rationales for informatics in education

What are the specific rationales for informatics in education? Educational policy-makers advance four principal ones: I shall call these the Social, Vocational, Pedagogic and Catalytic. The Social rationale says we should spread awareness of informatics thinly to the greatest possible number of students, because everyone needs to know a little about it. Computer literacy courses serve this rationale, but for them we require far more computers in our schools. The Vocational rationale aims at helping students towards informatics-related jobs, by teaching them computer science. These are the people we need to plug the gap of 100,000 by 1993. The Pedagogic rationale focusses on improving teaching and learning in a wide range of subjects. Micro-worlds can serve this rationale, if only we had more of them. The Catalytic rationale is based on a belief that bringing informatics into schools and colleges enables desired changes to occur, in their curriculum, in their teachers' approach to teaching and learning and in their management.

Dundee Insitute of Technology leads the way

Are Scottish educational institutions using informatics with such rationales in mind? From my own observation today, I would say that Dundee Institute of Technology is leading the way. It has a library already using informatics to a large extent, with CD-ROMs and on-line searching of remote databases. It has a very active computer centre providing a wide range of services to students and staff, to say nothing of what it can do for the business community. It has a Media Centre capable of producing first-class videos and other educational media. There is no doubt that Dundee can be proud of all this. Does the Institute provide computer literacy for many of its students? Does it teach computer science? Does it use informatics in many of its courses, across a wide range of disciplines? Has it re-oriented its approach to education through setting up the Educational Services represented here tonight? The answer is Yes, to a remarkable extent, considering the difficulties. Few students, and even fewer members of staff, can ignore what is happening and be successful. All have opportunities to exploit informatics to their own advantage, rather than be exploited by it. And, given the resources, these opportunites will grow and grow over the next decade. What a cause for celebration!

By the year 2000, who knows, the ghosts of the founders of the Institute may be communicating with the Computer Centre -- or will it be the Library or the Media Centre? They too may want to know about this business of informatics in education. And why shouldn't they? The Educational Services Board has indeed brought informatics into education here.

Milton Keynes, March 8, 1989

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