Virtual Learning

Introduction

For almost twenty years successive British governments have realised the importance of computers and computing and made significant investment in schools. The latest initiative, the National Grid for Learning, seeks to place online learning facilities at the heart of the curriculum for both teachers and students, and use it as a vehicle for Life Long Learning. School communities – students, their parents and their teachers – have struggled to manage technological change when resources, particularly those of time, have been stretched by the curricular and administrative changes they have had to implement.

The impact of Information and Communication Technologies (ICT) in the classroom transforms management, organisation and conventional pedagogical approaches. Many teachers still struggle with the demands of ICT in the classroom: the ICT training programme provided by the New Opportunities Fund (NOF) aims to provide the skills and theoretical framework within which educational praxis can absorb these changes. ICT is seen as an integral part of each strand of the National Curriculum, and the performance of teachers is to be judged on their ability to integrate ICT within their teaching and their students' learning.

From the mid 1990s, however, a significant number of students have gained access to a personal computer at home. The ways in which they have learned to use the machines, and the uses to which they are put, are shaped more by personal experience and input from their peers than by their schools. The programs they use, the ways in which they learn and the work they create mean that the education system struggles to meet the demands and expectations of these young people. What follows, of course, is that those who do not have this technology at home are doubly disadvantaged if their schools and teachers cannot compensate.

During this period these issues have been investigated by the author, and this book is based on several years' research into patterns of computer ownership and use among young

people. A six-year longitudinal study of some 1800 students at a comprehensive school in West Yorkshire provided the data from which the results were drawn. Student work was examined during this period, and students themselves commented on the ways in which computers had changed their work. Teacher use and teacher attitudes were also examined. The results clearly demonstrate the disparity between student computer ownership and use and that of their teachers.

The ways in which those people with computers learn how to use them have shaped their assumptions and expectations of what it is to learn. They are less likely to accept conventional pedagogical approaches as appropriate to them. The patterns of learning experienced by young people are at variance with the assumptions and expectations of their teachers, with profound implications for the education system.

When the investigation began, much then-current research focused on curriculum and institutional uses of ICT. Underwood and Underwood (1990) examined the whole-school use of ICT, Watson (1993) examined the impact of ICT on children's achievements and Wood (1998) evaluated Independent Learning Systems (ILS). Papert's work on LOGO has focused on cognitive gains from the use of that program. Turkle (1995) studied the impact of online communities and computer use among post-adolescent students.

What was missing from the literature was a study that examined the effects of home computer use among young people, and the ways in which this impacted on the education system. This study shows how the learning patterns of young people are now often shaped by the ways in which they use a range of technological tools: games machines and mobile 'phones, but particularly computers. The expectations about learning and work which these young people bring to their classrooms are in conflict with those of the school and their teachers. The learning patterns and learning gains need to be understood if they are to be capitalised upon by the education system. Without that understanding the efforts of schools, and the talents of students, may well be undermined. The citizens of the twenty first century are being taught in classrooms of the twentieth century whose praxis is shaped by the 1870 Education Act.

Computers present students with powerful tools for learning. Young people who use them have been set free from conventional expectations of learning. This raises profound issues for the educational system of the new century.

The context to the research

"As the use of a new technology changes human practices, our ways of speaking about that technology change our language and our understanding. This new way of speaking in turn creates changes in the world we construct."

(Winograd and Flores, 1988, p.6)

From 1984 to 1986 I worked in Dammam for the Saudi Arabian Language Institutes, and purchased an IBM-compatible computer for the office. Within a week the Palestinian secretary had compiled a database of all the clients, set up a spreadsheet to track income and expenditure, and was enthusiastically using a word-processor to generate correspondence. He taught himself, with the help of phone calls to friends and the occasional use of the manual. Six months later the routine operations of the office had been transformed, and Ibrahim, the secretary, was able to make suggestions as to the ways in which the administration of the Institute could be changed. The technology had empowered him. When I looked at other companies with which I came in contact I found, to a greater or lesser degree, the same process.

Many of the clerical workers in company offices had been recruited from Jordan, the Philippines, South-East Asia and the Indian sub-continent. They arrived to find a workplace very different from those which they had left. All the offices had installed computers, and the staff were expected to use them. When their contracts had finished many of these bought computers to take home and use in their own businesses. All to whom I spoke believed that these machines would transform their family businesses, and their lives. They saw computers as a means of giving them access to a technological revolution which would plug them into the developed world.

It was not simply that the utilisation of computers for office tasks had increased their efficiency: that tasks could be undertaken more swiftly and easily. The more profound

change was that these workers could envisage different ways of doing things. Their style of working could change.

British schools

In 1987 I returned to work in comprehensive schools in West Yorkshire. The Local Education Authority had chosen to equip all schools with Acorn microcomputers (usually referred to as 'BBC computers', after the promotional television programme.) I found that students and teachers were using Acorn BBC computers for very different tasks to those I had seen in use in the Middle East: here they were used as aids for learning mathematics or science; as a way of presenting final drafts of writing, or, in Business Studies, studying databases. Many enthusiastic teachers were struggling to fit computer use into existing schemes of work, or were teaching students about computers. I found very few examples of teachers - or students - using computers to transform the ways in which they worked, and the outcomes they produced. Computers were predominantly seen as external to the school process of learning and work, and to be used for specific purposes.

I considered that two aspects were central to the ways in which computers should be integrated into the education process. The first was how students could undertake work using a new tool. The second was whether this tool fundamentally changed the artefacts which were produced. These issues were rarely the focus of the way in which teachers used computers with their students.

The articles which I read on educational computing, and the courses run for teachers by the schools' advisory service, were more concerned with the skills which were needed in order to use the computers with students. The dominant approach was for teachers to learn how to use programs to achieve particular outcomes relating to their curriculum, and then to teach the students how to use the programs in order to achieve those outcomes. Students would use computers to learn how to produce grid references in Geography; to calculate the nutritional composition of meals in Food Technology or for word prediction in English using cloze exercises.

Much of the then-current research literature was devoted to the examination of ways in which the use of specific programs could reinforce and extend aspects of the curriculum and the learning process. (The occasional papers published by the Information Technology and Education Programme, (1986-88) and InTER (1988-90) Information Technology in Education Research Programme (ed. Lewis, R. 1986-90); University of Maryland: Human-Computer Interaction Laboratory; Northwestern University: The Institute for the Learning Sciences.)

Much of the software I encountered in schools had been produced by enthusiastic teachers, whose approach utilised game formats in which students were awarded scores to signify success. The paradigm of Computer Assisted Learning was dominant: short sessions on the computer for specific groups of students to reinforce the normal curriculum.

My professional reservations were that such a policy presented computers and their use as something which had to be taught and applied in specific ways, and that the students' role was no different from that in any other subject. Computers in schools were objects about which students had to be taught. Their use was seen in terms of skills which had to be learned before they could be applied. The power and independence which I had seen in colleagues in the Middle East, when computers were adopted with no formal instruction, suggested that this was not the most educationally beneficial application of the technology. However, it was an efficient way to utilize scarce resources. In such a context it was far easier to use computers to teach students about them, rather than allow students to use them.

Extending the technology

During the next three years the school at which I was working invested significant sums in extending computer provision. A whole-school network was put in place, new software was purchased, and new syllabuses adopted in Business Studies which provided opportunities for independent student work. Staff training sessions were organised to introduce teachers to the new possibilities.

Paradoxically, the increase in investment and the commitment to staff development did not seem to produce a corresponding increase in the use of computers across the curriculum. Where a department adopted computers as part of their work with students, computer work was added as additional units within the syllabus, rather than to transform student work. The Mathematics department scheduled a unit of work involving computers for each student in years seven and eight; the English department added a word processing unit.

There was no increase in the numbers of staff using computers as an integral part of work with the students. Those teachers who had embraced computers when they were introduced continued to develop their work. Most, though, saw them as irrelevant to their subject. The weekly timetables and booking sheets for the IT rooms would be used by the handful of staff who attended the IT Support and Development Group meetings. Other colleagues were reluctant to be persuaded to use the facilities. They would cite curriculum pressures that prevented them from taking classes to use the facilities, the unreliability of the machines or the difficulties of managing students in an unfamiliar environment.

Transformations

By 1990, however, the situation changed when a significant minority of students started to have access to computers at home that ran industry-standard software and which had printers. These computers were significantly different from those which students used for games playing or programming. In the majority of cases they were business machines which had been replaced, written off by the accountants and sold to employees for a nominal sum. The coursework these students produced in a range of subjects not only reflected the skills they had acquired at home, but also enabled them to produce documents that many referred to as 'real'. What was interesting was the fact that many students used databases, spreadsheets and graphics to support and illustrate points that they were making in their writing.

One consequence of this was that students were able to analyse data and view a number of graphical representations of it with very little effort. This ability to cycle through different charts and to view the data in different ways meant that students were able to decide which data sets were significant. In turn, this meant that their writing became more analytical: the

ability to generate and view a range of data representations meant that causal links could be tracked easily. The length of time which the process would have taken had the students created the graphs manually would have prevented them from contemplating the task.

Another, possibly more significant, consequence was that these students began to plan and organize their work in terms of the technology to which they had access. They would pressure their teachers to use school facilities: students without access to a home computer would add to the demand. Some teachers realised that their lack of expertise could be compensated for by involving IT-literate students as mentors to others within the class.

Investigating the changes

During the next three years a growing number of students with whom I came in contact spoke enthusiastically about the computers they had at home, the ways in which they used them and how these compared with the limitations of the school resources. By 1994 I decided to survey the whole school population to see whether this was indeed the case, or whether I was projecting the enthusiasm of a few students into an unsustainable generality. I also decided to survey students as to why they used computers: I wanted their perceptions.

The investigation of what the students did with computers, and an exploration of their reasons for doing it, required a methodology that would accommodate a range of responses and generate a typology. Previous research I had undertaken in student perceptions of genre in television, and the ways in which they used soap operas such as Neighbours and Coronation Street, suggested that a Uses and Gratifications typology (McQuail, 1987) might provide an appropriate way in which to approach the data. It was analyzed using a modification of McQuail's Taxonomy of Gratifications.

The first of the whole-school surveys was conducted in February 1995, the second in February 1996, the third in February 1997 and the final survey in February 1999. The data on home ownership of computers confirmed the initial supposition, that a significant number of students had access to these. Whilst many students had access to an IBM-compatible computer running a Windows operating system, in 1995 there was a

heterogeneous mix of machines cited by students as computers. Many younger students listed their games machines: others, older systems.

With each survey the impact of the PC on students and their work became more pronounced. The introduction of multimedia machines gave students access to a range of reference material: the last survey showed the impact of the Internet on students' working patterns. At the time of the final survey a computer using a Windows operating system – sometimes referred to as the 'wintel hegemony' - had become synonymous with the term 'computer' for all students.

The effects

A consequence of this is that students with a machine at home have shifted the site of production for their work from school to home: they feel more in control of their work, they don't have to compete for scarce resources at school, and they can use a newer system which they have configured for themselves.

The rate of change in the computer market and the emergence of computers as consumer goods made it difficult to ground this study in educational research. Much of the background evidence, therefore, was drawn from industry sources, where resources and funding were such that there was an immediacy to the data difficult to achieve in other circumstances. Surveys from manufacturers during this period (ICL, Olivetti, 1997, Microsoft, 1997) and consultancies (McKinsey and Co., 1997) supported the penetration of computers into the domestic market (Longman PC ownership survey, 1997). The McKinsey survey speculated as to ways in which home ownership of computers was likely to change the nature of compulsory education. When Microsoft provided their own Internet service it was described as 'a private education'. For many young people the concepts of computers, Microsoft programs, knowledge and education were becoming inextricably linked. Knowledge and learning were presented as commodities, to be purchased, and replaced when they need updating.

The implications

When computers were introduced in schools in the United Kingdom the computers to which children had access at home were often either machines used for generating programs, or dedicated games machines. Schools used a range of computers, from Acorn/BBC, through Commodore, Dragon and Research Machines, to those assembled by staff and students. A variety of operating systems, software and hardware could be found within those workplaces that had adopted microcomputers.

As 086 IBM PCs with Intel chips and MS-DOS operating systems became standardised in business, so they had an impact on students. With the increasingly rapid changes in technology companies adopted a faster write-down in their accounting policies, and 'obsolete' machines found their way into homes. When Windows became the de facto standard, students who acquired these machines suddenly found themselves with an extremely powerful machine to learn and use. These computers were increasingly identified by students with the adult world of business, and were therefore regarded as 'real'.

By 1995 PCs were promoted as consumer goods. Programs were distributed on the covers of magazines, and students found that they were able to learn how to use these and combine them with other programs in order to produce work for school. For the first time, a significant percentage of students in this country found that they could learn how to use something that most of the adults in their lives could not. These students worked out for themselves how programs were used: each of them learned slightly differently, and they traded this information at school.

Students are now continually experimenting with new programs, new applications and new technology. They are in a process of continual learning, which they control. They see that much of the computer technology which they have to use at school is older than theirs, with more limited software. More importantly, there is a level of institutional control that is imposed on their use of it that conflicts with their understanding of how the technology could be used.

The quotation with which this thesis opens suggests a social-constructivist approach to knowledge and learning.

"As the use of a new technology changes human practices, our ways of speaking about that technology change our language and our understanding. This new way of speaking in turn creates changes in the world we construct."

Winograd and Flores (1988) suggest that the changes which a new technology produces in our practice, the ways in which we work, should also effect a change in the ways in which we speak about our ways of working. If the ways in which we speak about something change, then the ways in which we understand things will also undergo a change, which should, in turn, change the ways in which we perceive the world and construct meanings from it.

If Winograd and Flores are correct, then these changes in student practices should effect changes in the language and understanding of students. These should then produce changes in the world they construct.

The research perspective

The research on which this thesis is predicated was conducted over a period of six academic years. It involved all the students in the school. The longitudinal surveys were undertaken in tutor time, and the sample size for each survey varied according to a number of factors: reliability of the school buses, small-group activities during tutor time and student absence. Nevertheless, between 1200 and 1300 students were surveyed during each phase of the research – up to 70% of the school population of 1800. A comparative survey compared these students and those from another comprehensive school in the city. The only comparable large-scale survey with which comparison could be made during this period was the Ultralab survey of emergent capabilities, which was single-phase.

Other surveys involved selected year groups: Years 7-10 and 12. These investigated student attitudes towards using computers for work and the perceived benefits; the ways in which they perceived the Mind and how it worked; the ways in which they thought they learned. Teacher surveys were also undertaken during the research: those from the school were

surveyed during the student surveys: those from other schools in the local authority at other times.

The perspective was essentially ethnographic, in that it examined the ways in which young people and their teachers used and made sense of constantly changing technology. This work is therefore about changing perceptions, expectations and conceptions, where knowledge and understanding are constructed with each new action and utterance, and where learning is just-in-time.

I was constantly surprised at the changes and developments the research revealed: my expectations were often subverted.

Towards a new Theory of Mind

The surveys of student computer use undertaken over more than five years of the study showed students using Information Technology tools to undertake tasks across the whole of their education. Key Skills has been embedded in the post-16 curriculum and in vocational training. The principles of the Literacy Hour and the Numeracy Hour have moved from the primary school into the secondary school. These Key Skills by any other name are likely to by joined by ICT. When that happens they will form the core curriculum for all students.

Surveys of teacher competence in the use and application of ICT during the same period have highlighted a growing disparity between students and their teachers. Where teaching in ICT takes place much of it is skills-based. It focuses on exercises, which are assessed on the basis of how well the student has fulfilled the expectations of the teacher and the assignment. The outcome is often a set of imperfectly-learned routines with limited transfer possibilities. This is particularly the case where schools have decided to allocate an hour a week to ICT as a taught subject, in order that National Curriculum responsibilities be met. The intention may be that ICT is to be taught as a tool, but because resources are often inadequate students rarely have the opportunity to use it as a tool except in tightly controlled circumstances.

Interviews with students, however, indicate that their starting points for work are what they already know, and what is available for their use. The conventional instructional paradigm

holds that the learner is introduced to a new program, practises the skills and then applies them in a relevant task. However, this is not that which students apply to their own Information Technology use.

Tasks which students undertake represent the unknown: they try to solve problems and complete work at the same time. The old paradigm of learning, practice and application has little relevance to tasks which they undertake. The constant updating of hardware and software means that few schools have the resources or the time to ensure that students learn, practise and apply their ICT skills. What is happening is that students apply the programs they have to the task in hand, and try to learn the routines as they go along. The use of the tool becomes shaped by the outcome, and the skills develop through use. The practice becomes one of 'do-it-yourself', in which items are taken 'off the shelf' and used in whatever way the constructor sees fit.

The French term for this is 'bricolage' - whether for a do-it-yourself store, a builders' merchant or the act of constructing an artefact in this way. In 'The Savage Mind' (1962) Levi Strauss used the term 'Bricolage' to describe the way in which the non-literate, non-technical Mind of 'primitive' man responds to the world around him. The process involves a 'science of the concrete' which is carefully and precisely ordered, classified and structured by means of its own logic. The structures are 'made up', and are ad-hoc responses to an environment. They establish homologies and analogies between the ordering of nature and that of society, and 'explain' the world and make it able to be lived in. The bricoleur constructs the 'messages' whereby 'nature' and 'culture' are caused to mirror each other. Levi Strauss saw bricolage as a way in which pre-scientific societies construct a belief system which explained their world.

Papert (1980) used the concept of bricolage in relation to the concept of 'chunking' (Miller, 1956), a process in which knowledge is broken into 'Mind-size bites', which enables new knowledge and understanding to be constructed from it. His thesis was that the use of previously learned strategies - specifically LOGO routines - could be used as a tool by children in concept formation.

Levi Strauss' explanation of bricolage and the bricoleur offers an insight that is, perhaps, more applicable to our students.

…a bricoleur is someone who works with his hands and uses devious means compared to those of a craftsman…(he) has nothing else at (his) disposal. … The bricoleur is adept at performing a large number of diverse tasks…the rules of his game are always to make do with 'whatever is at hand'. (p.17)

The process used by students, then, is one of working from the specific (the assignment or task that must be completed) to the general (learning from that experience to apply to future experiences). The signs by which they work are those of the Graphical User Interface, with its buttons, toolbars, the ability to undo errors and print preview work in progress. The 'devious means' which they use involve templates and wizards, making do with 'whatever is at hand'. Their work gives an account of their lives in a world where allusion, reference and quotation seem the only possibility.

"We have already noticed the connection between…the activities of the…bricoleur and the modus operandi of the jazz musician. …This art, - an art of signifiers, not signifieds, can be said to be truly modern…"

(Hawkes, 1977 p.121.)

If the analogy of 'do-it-yourself' is developed, then one needs to examine the tools and materials that a bricoleur can find to hand.

The toolbox

The toolboxes with which students work can be found at home, amongst their peers, and in educational establishments. The ubiquitous personal computer with a 3.5-inch disk drive can be used to achieve at least part of whatever task is in progress. A collection of floppy disks will store all of the parts that have been fabricated: the artefact will be assembled in whatever space offers the best facilities. A CD-writer extends the range of possibilities, whilst online storage resources can be accessed by students from whatever location for whatever purpose, be it individual or collaborative.

The diversity of information technology provision in educational institutions is a by-product of the speed of technical change and of the continuous consumption predicated by built-in obsolescence. The same pattern can be found amongst individuals: what was state-of-the art six months previously is no longer marketed. The cutting edge of technology slices the market into as many segments as there are owners, many of whom imagined that their purchases would have the same life span as other consumer items such as video recorders or washing machines.

Students learn to use a range of tools in whatever way they can. Old 286 machines can be used to create and edit text and data: a 386 will be used for that, and more. Computers with a 486 processor serve as workhorses, whilst the serious work is done on the newest, fastest machines with the largest memory and the biggest hard drives. Scanners and digital cameras will grab all the images that are needed. Institutional Internet access, with greater bandwidth and faster connection speeds than at home will provide serendipitous information sources.

The Tools

"…the engineer works by means of concepts and the 'bricoleur' by means of signs."

(Levi-Strauss, 1962; 1972 p. 20.)

Throughout the research it has been noted that students work with whatever software tools are to hand. These tools range from the basic integrated Works packages installed on educational networks, through those, like Lotus SmartSuite, Corel WordPerfect Suite or Star Office, which are bundled (for market share) with machines sold into the domestic market, to the latest incarnation of Microsoft's Office. The more enterprising students download freeware or beta versions of programs from the Internet. DTP programs, publishing packages and presentation software are all available, to be picked up and used when they are needed. The CD-ROM cover disks that are given away with computer magazines are passed around if they contain games, programs or useful utilities. Oracle's Think.com links students to world-wide collaborative communities and provides a forum for publishing.

Students work with Wizards in order to short-cut the learning curve. Wizards provide a way in which users can approach a task for the first time and be guided through a range of

options. Auto-content and templates provide ideas and suggestions: choices are provided which users can accept or reject at will; preview possibilities and choose the one most appropriate to their needs. They offer a framework for learning in which the learner is in charge.

Success with one piece of work encourages further experimentation: the main skill that is learned is the speed with which things can be learned.

What remains to be done by the student is to knit together all of the work created by these tools. Students learn how to save and import in various file formats. Having done so, they pass that knowledge on to others. Work is copied from one application and pasted into another. All these are done in the teeth of rapidly approaching deadlines: writing, creating and editing are simultaneous. As each part of the edifice is put into place it is saved: if it does not look right, or if the structure topples, then the UNDO command restores the status quo. In this way, numbers of pieces can be tried out, considered and modified before the deadline arrives and the work is submitted. The process is one of intuitive navigation through a series of mid-course corrections. Students have often referred to this as 'tweaking' or 'tinkering'.

The Materials

"…he 'speaks' not only with things…but also through the medium of things: giving an account of his personality and life by the choices he makes between the limited possibilities."

(Levi-Strauss, 1962; 1972 p. 21.)

This Do-it-Yourself approach affords equality to all materials. Student-generated text is no more privileged a discourse than text downloaded from the Internet, saved from a CD-ROM or scanned from other text sources. Images taken from clip art collections are modified at will and used in conjunction with others scanned from books, magazines and photographs or grabbed by video capture. The Web is seen as an infinite resource of images and code as well as information. These materials, then, are seemingly endless: the needs of the task, the tools to hand, the knowledge pool and the time available are the only constraints.

The Artefacts

An artefact that illustrates the dilemma which this poses to educational institutions was produced in response to a Year 9 Geography assignment which was set at Boston Spa Comprehensive School. This required students to research and write a paper on earthquakes. Responses varied from handwritten explanations drawn from a range of textbooks with appropriate hand-drawn coloured diagrams, through bald summaries of lesson notes, to work resourced from, and produced through, ICT. The most imaginative example of the latter category was produced by a student who utilised diagrams from Encarta entries, saved a sequence of images from the video clips as individual frames and chose text samples to illustrate the process. These were then copied and pasted into a document and presented as his own work. His (original) written contribution was a series of headings and an explanatory commentary.

This assignment elicited a number of responses from teachers. Many thought that the report somehow short-changed the educational process. The student admitted that the report had been completed in half an hour. Many students had spent weeks on their reports, struggling to share library books and produce neat work. Nevertheless, in terms of both cognition and outcome the student with a home PC and Encarta had achieved what the assignment intended.

Presentation software provides enhanced opportunities for students to embed headings and explanatory commentary in a format that uses images and effects to communicate. These postmodern collagistes cut and paste images into the presentation framework and thread their message through the medium. The information is carried both visually and textually.

In an early (1996) example of PowerPoint by a Year 12 GNVQ Business (Advanced) student, images and text were combined to illustrate a talk on employment and the law. As with many such presentations the student incorporated text from the report into the slide show. The result was that effect of the image is minimised. The amount of text meant that the value of the image was more decorative than semiotic. By the following year students were adapting their style to match the presentation. Standard layouts and images from PowerPoint were still used, but the quantity of text had reduced.

Year 11 students in a GCSE Geography project the same year (1997) collaborated to produce a report of their field trip. The majority of the images were drawn from the clip art library, but a map had been scanned and inserted into the presentation. Student annotated the images with points from their study. By the following year students undertaking the same project were thinking in terms of digital cameras and scanners. An increasing number of computers targeted at the consumer market were bundled with these peripherals. Three of the images in their sequence were digitised photographs. The fourth image had been scanned from an existing picture.

As students gained increased access to computers in school and at home, the level of complexity of their work increased. Their slides demonstrated complex editing, with a range of images and techniques incorporated into the final product. When a Geography teacher set homework, one Year 9 student simply inserted images and selected text from the multimedia encyclopaedia Encarta into PowerPoint templates. These were then printed out and used as coursework. In later examples images were downloaded from the Web and incorporated into a presentation templates.

Web pages produced by students used a similar design approach: page design was often based on that produced by others: source code for images and effects copied and pasted into the students' own sites. Indeed, hosts such as GeoCities distribute free utilities to encourage web site construction.

The Problems

The post-modern positioning and conditioning of students, accessing, copying and swapping a range of media, extends to the work that they do. They regard the artefact they produce for assessment as their product: they have designed and created it. In essence, it is a post-copyright product. In their world, what are the ethics of ownership? What are intellectual property rights in the Information Age? What is plagiarism?

A presentation made by a Year 12 GNVQ (Intermediate) student to report on his work experience integrated word processing, PagePlus (a DTP program) and stock clip art from PowerPoint. The student also used the Print Screen facility to save screen shots which

illustrated the tasks he undertook on work experience. These were then integrated with the rest of his work. The main signifiers on the slides were the images: the text simply supplied the detail. The student had started to move away from a dependency on text. Whilst undertaking work on a database during his work experience the student selected the 'Print Screen' option and saved the image to his floppy disk. On his return to school the image was imported into a DTP program, text superimposed, then copied and pasted into the PowerPoint file.

In an ideal world there would be time, resources and expertise enough to ensure that the educational process empowered all of our students equally. What we see, however, is that in this Information Age, those with access to the economic and cultural capital which computers represent are privileged.

"I got my first computer when I was five. I've had lots since then. I always use them."

(Year 12 GNVQ Student.)

These students envisage any tasks which they are set in terms of the resources and routines which they will use. The proportion of their week in which computers are used is considerably greater than most of their teachers. Apart from access during timetabled lessons, students have access before school, at break, during lunch-times and after school. When they go home to work many of them switch on their computer. (Year 7: 47% Year 10: 62%; Year 12/13: 72%). It is only to be expected that their proficiency should be more extensive.

When the starting position of many students is compared with that of their teachers it becomes clear that it is critical to develop a range of strategies to cope with the ways in which many school students work. The first imperative is that information seeking and handling skills should be taught as an integral part of the curriculum from the earliest age. The second imperative is that schools and teachers address the issue of those students who do not have access to a home PC. A policy of positive discrimination may be needed. It may be necessary to re-define our expectations of coursework in order that no group of students is disadvantaged: neither those from non-digital households, nor those who are

electronic magpies, plucking glittering items from whatever source they find and constructing their artefacts.

A key issue is that students be taught the attribution and ethical use of materials. Plagiarism of a textbook is easier for a teacher to identify than that of a plethora of electronic information. Those students who have CD-ROMs and an Internet connection at home have access to an unlimited source of information which teachers cannot control, or indeed identify.

The progress of these cyborgs from the classroom into higher education inevitably raises questions about the nature of authenticity and originality of their work. The issues raised are ones that are of direct concern to teachers. If they are not addressed at an early enough stage in the educational process there may well be two inevitable consequences:

more ammunition will be handed to those critics of the expansion of higher education, who would argue that true learning is the province of the few, rather than the resource of the many;

those students whose understanding and use of computers is limited by their lack of access will be further marginalised.

A new (autonomous) way of working?

The process used by students, then, is one of working from the specific (the assignment or task that must be completed) to the general (learning from that experience to apply to future experiences). The signs by which they work are those of the Graphical User Interface, with its buttons, toolbars, the ability to undo and print-preview work in progress. The 'devious means' which they use involve templates and wizards, making do with 'whatever is at hand'. Their work gives an account of their lives in a world where allusion, reference and quotation seem the only possibility. The dominance of a post-modern culture, which resists both privileged readings and traditional narratives, suggests an outlook very different to a Hegelian sense of thesis, antithesis and synthesis.

What do you do when you have to learn and those who should teach you don't know?

The background of many teachers in the past thirty years has been based on the concept of developmental stages in learning (Piaget, 1958). This posits three main stages through which the learner must pass - sensori-motor, concrete and iconic - before anything of significance can be produced. Much of the pedagogical culture of schools (and teacher ideology) is loosely based on a conflation of these stages and 'developmental readiness'. Teacher input, student practice and application (or transfer) are often assumed to be the appropriate model for student learning. The education system itself, with its primary - secondary - tertiary divides, and the ways in which educational resources are allocated, provides the material base for this superstructure.

Learners with access to computers have established a different material base. The speed and capability of machines, with their 'Point and Click' ostensiveness, templates and wizards, have usurped their teachers' paradigm. Learners practise the skills and concepts whilst applying them: where input or explanation is necessary the task will be suspended. The Help facility, a magazine article or a conversation with a friend should resolve the problem. Only rarely will the student consult the user manual.

To the thesis of Stages of Learning there is now an antithesis: There Are No Mistakes. The alterations in the task are part of the learning. Students use Edit: Undo; Edit: Clear or Exit: Don't Save. The process is auto-didactic.

The material base of computer access supports a superstructure with its twin pillars of apparent wisdom. The first assumption on the part of many students is that "the answer is out there": that information access through the use of CD-ROMs and the Internet, and information handling through cutting and pasting and downloading, will somehow lead to knowledge and understanding. The second assumption is that the most important aspect of a piece of work is its originality in creative terms. The creation of artefacts is a process of self-expression; the do-it-yourself of bricoleurs.

The synthesis must be that learning is seen as experiential, observational and a semiotic experience. The question of content, contentious when what has been done is not worth learning, must not be subverted by electronic form.

Concern over the subversion of content by electronic form has been identified as 'data dandyism' (Lovink 1995). He describes those who are "…concerned with…the accumulation of as many immaterial ornaments as possible…", where digital style triumphs over substance. The ornaments are a reflection of both technical skill, in that the 'data dandy' demonstrates superior competence, and technical sophistication, in that the user possesses the latest, most powerful (and most expensive) hardware, software and peripherals. The sub-text is that the user has sufficient time to devote to the acquisition of such skills. This demonstration of social worth through cyber semiotics updates the concept of fashion and conspicuous consumption (Veblen, 1899).

Or is the substance inseparable from the style?

"…a bricoleur is someone who works with his hands and uses devious means compared to those of a craftsman…(he) has nothing else at (his) disposal. … The bricoleur is adept at performing a large number of diverse tasks…the rules of his game are always to make do with 'whatever is at hand'.

…the engineer works by means of concepts and the 'bricoleur' by means of signs.

…he 'speaks' not only with things…but also through the medium of things: giving an account of his personality and life by the choices he makes between the limited possibilities."

(Levi Strauss)

"We have already noticed the connection between…the activities of the…bricoleur and the modus operandi of the jazz musician. …This art, - an art of signifiers, not signifieds, can be said to be truly modern…"

(Hawkes)

Our post-modern bricoleurs in cyberspace

Do-It-Yourself for Cyborgs.

Use the bits of Information and Communications Technologies to construct metaphors for who you think you may be.

Be a Bricoleur of the Future, for the Future.

Conclusion

The hypothesis that framed my study was that of Winograd and Flores (1988).

"As the use of a new technology changes human practices, our ways of speaking about that technology change our language and our understanding. This new way of speaking in turn creates changes in the world we construct."

My initial assumption was that the changes that I would identify in the ways in which young people used the technology, and the changes it produced in their understanding, would relate to their ability to handle, present and process data.

The surveys I conducted for the first three years of this research investigated the material conditions of computer ownership, the understanding of computers which the young people possessed, and the uses to which they were put. During the first survey the definition of 'computer' was broad enough to include a number of machines that were used for games, although the owners were under no illusions as to their use. It was the technology to which the label 'computer' was applied, rather than the application. Other students identified older machines as suitable for practice in programming. The consensus among students at the school, however, was that a 'real' computer was one which contained an Intel processor and used a version of the Windows operating system. This perception was one that had been formed outside school, the dominant influence of which was the environment of work and employment.

What also emerged during the early surveys was the clear distinction made by students as to the way in which computers were used at school and the ways in which they were used at home, even though the work was being produced for school. It was clear that students regarded their systems as an extension of themselves and their personality: the ways in which they used the machines constituted an act of creation.

Very few of these students had received specific teaching in ICT at school: what teacher input there had been had been related to how to use programs on the school network and how to apply these to specific curriculum tasks. In other words, these students had learned how to use the systems themselves. As the proportion of students with access to a computer at home increased so did the number and types of programs they used. CD-ROMS and disks containing applications were regarded as common property: students would install a program, try it out and if useful keep it; if not, delete it. Their relationship with their computers is dynamic. They are in a process of continual learning which they control. By contrast, their relationship with school systems is restricted and static.

The changes in the world these students constructed have been ones of cognition and learning. Computers act as a vehicle for the combination of motor skills, manipulation, language and symbolic manipulation, through practical activities. These activities can range from the installation of programs, through playing games in virtual environments to undertaking a multiplicity of tasks for coursework. The software they use predicates a greater range of possibilities, as the activities for which it is used become more complex.

My initial supposition was that the rule-governed nature of software would produce a systematic approach to tasks that involved data handling and its presentation. That does not appear to have been the case. It is, rather, the plasticity of software and the GUI environment that has presented students with the ability to innovate. It is the ease of experimentation that this offers that liberates the bricoleur within individuals.

The point-and-click environment which students utilise reinforces the power of ostensiveness, the operation of pointing, which reinforces learning through representation by imagery and perceptual organisation. The images are the translation into visual form of prior linguistic and mathematical rendering: students perceive and use the icon as an entity in

its own right. This is the 'virtual reality' - not the theoretical underpinning of which it is the iconic representation. The spatio-qualitative qualities and properties of the events which the icons on the screen invoke are subsumed by the act of creation and the object that is created.

The concepts of Mind which the students form are those associated with creativity and originality. These construct the individual's sense of identity. It is a learned construct. For the first time learners have a machine for learning that is powerful, interactive, flexible and personalised. The changes suggested by Winograd and Flores are a product of this, but they are continual changes, a dynamic, the outline of which is only starting to emerge. They have produced an independence in the learners who use computers which is increasingly at variance with institutional expectations of learning, and the relationship between school students and the institution.

For these students, knowledge is in the constructive process: it is concerned with the making of ideas, rather than in finding them to solve a pre-determined problem. In cognitive terms it produces second order cognitive knowledge, which enables students to work things out for themselves and to interpret new structures, rather than first-order tasks, which tend to be teacher-directed (Stevenson, 1998).

Indeed, much research literature is still focused on the institutional perspective. Concern is raised over the effects of multimedia when used in an instructional context: the assumption is that there is an inherent contradiction between the learning styles associated with multimedia and the Internet and the educational process (Salomon, 1998). The critique is extended to ICT in American education, and the conclusion reached is that it has produced negative effects (Oppenheimer, 1997). Seymour Papert (1996), on the other hand, approached the subject from the opposite perspective: bottom-up, rather than top-down. His chosen analogy is horticultural: "Give everybody a computer, and then here and there more and more people will find interesting things to do with those computers and new ideas will spontaneously grow."

The model of the education system, based on hierarchical, industrial, modernist assumptions, is one that at present sits uneasily with its subjects. They control their

technology: the productive capital. They create their cultural capital. They share a symbolic capital common to those who live in the post-industrial, post-modern digital virtual world.

The challenge for teachers in the classroom is that of presenting the curriculum and the learning process in ways which will enable all to succeed. Those whose intellect and learning style is shaped by their ICT environment must be taught the disciplines of information handling and attribution. Those who are dependent on school-based resources must be provided with an environment in which intellect can be enriched.

The challenge for society and institutions is to incorporate this new reality into their pedagogy and epistemology and ensure that all can benefit from it. If the challenge is not met the structural and cognitive inequalities that will result will impoverish us all.

Reflections

A significant number of students expect to do most of their work at home, rather than at school.

Many students regard the knowledge of how to do things as more important than subject knowledge.

Their computers are vehicles for learning: the routes they use to learn are not those found in most classrooms.

The computer has become the integrating focus for the verbal-linguistic; logical-mathematical; visual-spatial and bodily-kinesthetic intelligences described by Gardner. All these combine in the process of learning for young people.

When knowledge is constructed by the students the teacher finds it very difficult to be a gatekeeper.

New routes, new roles

The research has explored a number of problematic areas in the use of computers by young people. There is no easy solution to their resolution: indeed, we may be trying to solve tomorrow's problems with yesterday's concepts. What follows is an outline of areas for further investigation and work.

Work at home

Many students have moved the site of production from school to home, because that is where their computers are. Their perception is that such work is more highly rewarded by their teachers. They also find it more 'fun'. This generates two additional problems: students without a PC at home may well be disadvantaged further and the nature of work and behaviour in the classroom changes. Teachers find themselves managing groups of young people who do not expect to produce work in the classroom. Where much of the time in secondary school classrooms is devoted to tasks which reinforce learning the perception of both students and teachers must change. The construction of 'work', and its relation to learning, marking and assessment will require some adjustment.

Tools at home

The tools available to many young people: multimedia encyclopedias and reference works on CD-ROM, scanners and cameras for manipulating images and Internet access, call into question the nature of knowledge and how we assess it. Where there is a growing perception that knowledge is inscribed within the artefact students must be taught the skills of information handling and the associated ethics, particularly those related to plagiarism.

School a PC free zone?

School budgeting problems, resourcing issues, concerns over equality and a shortage of suitably skilled and motivated staff could lead some to imagine that the solution is to return to the classrooms of yesterday. If students are accessing information and learning autonomously at home, forming their own intelligence communities, then one role for

schools may be to focus on issues other than those involved with ICT. Given the status of ICT within the National Curriculum, the National Grid for Learning, the Virtual Teachers' Centre, and government initiatives to empower young people through 'computer literacy' this is not likely to be an option.

Integrate ICT possibilities into curriculum

The alternative is to integrate ICT within the curriculum. Display technologies, such as those of interactive whiteboards, the use of intranets and the Internet, the falling price of palmtop computers and the development of the National Grid for Learning all suggest that the technology is available if the will to use and integrate it is there.

PC to follow TV?

During the course of this study the PC has become ubiquitous among students at the school. The convergence of computers, Internet, multimedia, television and telecoms may well mean that our current concerns are a passing phase. In the same way in which television and video is used for teaching without having to be taught, we may find that ICT and computers become so embedded within our praxis that they are no longer an issue.

The emergence of WAP mobile telephony, the use of hand-held computers and Internet access through digital television are all indicators of the pervasive nature of ICT. Digital television web access, with bundled office utilities, may make online learning a reality for much of the population. The membership of online learning communities with global links, such as Oracle's Think.com, may help to reduce the digital divide.

Whilst this may be true for developed economies, the Less Developed Economies that contain most of the world's children have little chance of providing their young people with these opportunities. An understanding of this should form part of the ethical responsibilities which our students must assume. As they take a more active role in society it is to be hoped that they are able to contribute to the global economy for the benefit of all its citizens, rather than simply as beneficiaries of low consumer prices for the computer equipment they use.

Bibliography

Bateson, M. (1972), *Steps to an ecology of Mind,* New York, Ballantine Books.

Birnbaum, L. (1991), *Three Critical Essays on Language and Representation*, Northwestern University, The Institute for the Learning Sciences.

Blair, A. (1998), Announcement of government spending on information technology in schools, *The Times*, 07.11.98., *The Independent*, 07.11.98.

Bourdieu, P. (1986), The forms of capital, In: *Handbook of Theory and Research for the Sociology of Education*, Ed, Richardson, J.G., New York, Greenwood Press.

Bourdieu, P. (1993), *The Field of Cultural Production*, Cambridge, Polity Press.

British Computer Society (1997), ICT in Schools, *Computer Bulletin Supplement.*

Bruner, J. S. (1966), *Towards a Theory of Instruction*, Cambridge, MIT Press.

Bruner, J. S. (1974), *Beyond the Information Given*, London, George Allen and Unwin Ltd.

Bruner, Oliver and Greenfield (1966), *Studies in cognitive growth*, New York, Wiley.

Chomsky, N. (1972), *Language and Mind*, Harcourt Brace New York.

Clements, D.H., Gullo , D.F. (1984), Effects of computer programming on young children's cognition, *Journal of Educational Psychology*, Vol. 76: pp. 1051-1058.

Clements, D., Meredith, J. (1985), *Research on Logo: Effects and Efficacy*, State University of New York at Buffalo.

Clements, D.H., Nastasi, B.K. (1985), Effects of computer environments on social-emotional development: Logo and computer-assisted instruction, *Computers in the Schools*, Vol. 2 , Nos. 2-3, pp. 11-31.

Clements, D.H., Nastasi, B.K. (1988), Social and cognitive interactions in educational computer environments, *American Educational Research Journal*, Vol. 25, pp. 87-106.

Clynes, M., Kline, N. (1960), In: *The Cyborg Handbook* Ed, Gray, Figueroa-Sarriera, Mentor, S. (1995), London, Routledge.

Cox, M.J. (1997), *The effects of Information Technology on Students' Motivation*, NCET, Coventry.

DfEE (1997), *Excellence in Schools*, White Paper on standards in education, Cm3681, London, Department for Education and Employment (DfEE).

Donaldson, M. (1987), *Children's Minds*, London, Fontana.

Dwyer, D. (1994), Apple classrooms of Tomorrow: What we've learned *Educational Leadership*, Vol. 51, No. 7, 4.

Eco, U. (1976), A *Theory of Semiotics*, Bloomington: Indiana University Press/London: Macmillan.

Elliott, C. D. (1992), *The Affective Reasoner: A Process Model of Emotions in a Multi-agent System*, Technical Report No. 32 Northwestern University The Institute for the Learning Sciences.

Felder, M., Soloman, B. (1998), *Learning Styles and Strategies*, North Carolina State University, Http://www2.ncsu.edu.

Gardner, H. (1983), *Frames of Mind, The Theory of Multiple Intelligences*, London, Heinemann.

Gardner, H. (1993), *The Unschooled Mind, How Children Think and How Schools Should Teach*, London, Fontana.

Gopnik, A., Melzoff, A.N. (1997), *Words, Thoughts and Theories*, Cambridge, MA, MIT Press.

Gray, C.H. (1995), *The Cyborg Handbook,* London, Routledge.

Griffith, M., Miller, H., Gillespie, T., Sparrow, P. (1999), Internet usage and internet 'addiction' in students and its implications for learning, *Journal of Computer Assisted Learning* Vol. 15 No. 1, pp. 89-90.

Haraway, D. (1985), The Cyborg Manifesto, Science, Technology and Socialist-Feminism in the late Twentieth Century, In: *Simians, Cyborgs and Women* (1991), London Free Association Books.

Hawkes, T. (1977), *Structuralism and Semiotics,* Methuen, London.

Horner, C.M., Maddux, C.D. (1985) The effect of Logo on attributions toward success, *Computers in the Schools*, Vol. 2 Nos2-3: pp. 45-54.

Hughes, M., Macleod, H. (1986), Part II: Using Logo with very young children, In: *Cognition and Computers: Studies in Learning*, Lawler, et al.,, (eds), Chichester, Ellis Horwood.

Information Technology and Education Programme:

ITE/12/86 Lewis, R. *Some Aspects of the Classroom Processes.*

ITE/18/86 Moore, J.L. *Computer Education Activities and Pupils' Attitudes to Computers.*

ITE/13/86 Lewis, R. *Teacher-Fellowship Research Programme.*

ITE/20/87 Saunders, M., Machell, J. *CBT Evaluation Techniques and Processes – An Interim report.*

ITE/24/88 Lewis, R. (ed), *DES/ESRC Teacher Fellows 1986/7: - abstracts of research.*

ITE/25a/88 Lewis, R. (ed), *Research in Progress.*

ITE/25b/88 Lewis, R. (ed), *Research in Progress.*

ITE/26/88 Lewis, R. (ed), *Learning through Microworlds.*

ITE/28a/88 Wellington, J. *Policies and Trends in IT and Education.*

Information Technology in Education Research Programme (InTER), 1988-93:

InTER/2/88 Cumming, G. (ed), *Artificial Intelligence Applications to Learning and Training.*

InTER/3/1988 Eraut, M., Holes, C. *Groupwork with Computers.*

InTER/4/1988 Driver, R., Scanlon, E. *Conceptual Change in Science.*

InTER/6/1988 Macdonald, B., Stronach, I. *The Independent Policy Evaluation.*

InTER/7/1988 Lewis, R., Mace, T.D. *Support Tools for Authoring.*

InTER/9a/1989 Bryson, M. *A guide to the Electronic services.*

InTER/10/1989 Rymaszewski, R. *Information Technology and Language Development.*

InTER/11/1989 Rhodes, V. *Barriers to Innovation.*

InTER/12/1989 Hodgson, V., Lewis, R., McConnel, D. *Information Technology-based Open Learning – a Study Report.*

InTER/13/1989 Lewis, R., Mace, T. *Authoring Tools for simulation-based CBT – an interim project report.*

InTER/14/1990 Boots, M. *Research in Progress.*

InTER/15/1990 Rhodes, V., Cox, M. *Current Practice and Policies for using Computers in Primary Schools: implications for training.*

InTER/16/1990 Cumming, G., Lewis, R. *Exploration and Reasoning – a seminar report.*

InTER/17/1990 STAC Project Team *Supporting Technology across the Curriculum.*

InTER/18/1990 McMahon, H., O'Neill, B. *Capturing Dialogue in Learning.*

Inhelder, B., Piaget, J. (1958), *The Growth of Logical Thinking from Childhood to Adolescence*, London, Routledge and Kegan Paul.

Jameson, F. (1991), *Postmodernism, Or, The Cultural Logic of Late Capitalism*, Durham, Duke University Press.

Jarvela, S., Niemivirta, M. (1999), The changes in learning theory and the topicality of the recent research on motivation, *Research Dialogue in Learning and Instruction*, Vol. 1, No. 2, pp. 57-65.

Kapa, E. (1999), Problem-Solving, planning ability and sharing processes with LOGO, *Journal of Computer Assisted Learning* Vol.15 No. 1, pp. 73-84.

Kass, A.M. (1990), *Developing Creative Hypotheses By Adapting Explanations*, Northwestern University, The Institute for the Learning Sciences.

Kolb, D. (1984), *Experiential Learning: Experience as the Source of Learning and Development*, New Jersey, Prentice Hall.

Leask, M., Pachler, N. (eds), (1999), *Learning to teach using ICT in the secondary school*, London, Routledge.

Leiber, J. (1991), *An Invitation to Cognitive Science*, Oxford, Basil Blackwell.

Levi Strauss, C. (1962), *The Savage Mind*, Oxford, Oxford University Press.

Levinson, P. (1997), *the soft edge* London, Routledge.

Longman (1997), *PC ownership survey* Cambridge, Longman Logotron.

Lovink, G. (1995), *The Media Gesture of Data Dandyism* CTHEORY Theory, Technology and Culture, Concordia, Canada http://www.ctheory.com/ (27.11.1996)

McKinsey and Company (1997), *The Future of Information Technology in UK Schools*, London, McKinsey and Co.

McQuail, D. (1969), *Towards a Sociology of Mass Communications*, London, Macmillan.

McQuail, D. (1987), *Mass Communication Theory*, (2nd ed,), London, Sage.

McQuail, D. (ed,), (1972), *Sociology of Mass Communications*, Harmondsworth, Penguin Books.

McQuail, D., Windahl, S. (1981), *Communication Models for the Study of Mass Communications*, London, Longman.

McShane, J. (1991), *Cognitive development: An Information Processing Approach*, Oxford, Basil Blackwell.

Matthew, G.B. (1994), *The Philosophy of Childhood*, Harvard University Press Cambridge, MA

Maturana, H.R. (1970), Biology of Cognition In: Maturana and Varela: *Autopoiesis and Cognition*, Reidel Dordrecht.

Monteith, M. (1996), IT: home and school Microscope *(48), Autumn 1996*

OFSTED (1998), *Secondary Education 1993-97, A Review of Secondary Schools in England*, Office for Standards in Education (OFSTED), London.

Oppenheimer, T. (1997), The Computer Delusion, *The Atlantic Monthly*, July 1997, Vol. 280, No. 1, pp. 45-62.

Papert, S. (1980), *Mindstorms Children, Computers and Powerful Ideas*, The Harvester Press, Brighton.

Papert, S. (1996), Looking at Technology through School-Colored Spectacles, *The Electronic Policy Network*, http://epn.org/conferen/spapert.html. (10.02.99)

Pea, R.D. (1992), *Practices of Distributed Intelligence and Designs for Education*, Technical Report No. 21,The Institute for the Learning Sciences.

Pea, R.D., Gomez, L.M. (1992), *Distributed Multimedia Learning Environments: Why and How?* Technical Report No. 25 Northwestern University, The Institute for the Learning Sciences.

Piaget, J. (1953), *The Origin of Intelligence in the Child*, London, Routledge and Kegan Paul.

Piaget, J. (1972), *The Principles of Genetic Epistemology*, London, Routledge and Kegan Paul.

Piaget, J. (1968), *Structuralism*, London, Routledge and Kegan Paul.

Preston C., Harris S. (1993), *Software in Schools*, Slough, NFER.

Preston C., Cox, M., Cox, K. (2000), *Teachers as Innovators, An evaluation of the motivation of teachers to use information and communication technologies*, London, MirandaNet.

Ricoeur, P. (1978), *The Rule of Metaphor*, London, Routledge and Kegan Paul.

Salomon, G. (1998), Novel Constructivist Learning Environments and Novel Technologies: Some Issues To Be Concerned With, *Research Dialogue in Learning and Instruction*, Vol. 1, No. 1, pp. 3-12.

Sapir, E. (1921), *Language*, New York, Harcourt Brace.

Sapir, E. (1947), *Selected Writings in Language, Culture and Personality*, Berkeley and Los Angeles, University of California Press.

Schank, R.C., Jona, M.Y. (1990), *Empowering the Student: New Perspectives on the Design of Teaching Systems*, Evanston, Il, Northwestern University, The Institute for the Learning Sciences.

Schank, R.C. (1990), *Teaching Architectures*, Technical Report No. 3 Evanston, Il, Northwestern University, The Institute for the Learning Sciences.

Schank, R.C., Edelson, D.J. (1990), *A Role for AI in Education: Using Technology to Reshape Education*, Technical Report No. 1 Evanston, Il, Northwestern University, The Institute for the Learning Sciences.

Schostak, J. (1988), *Breaking into the Curriculum: the Impact of Information Technology on Schooling*, London, Methuen.

Searle, J.R. (1995), *The Construction of Social Reality*, Harmondsworth, Allen Lane.

Searle, J.R. (1992), *The Rediscovery of the Mind*, Cambridge, Ma, The MIT Press.

Seigel, L., Brainerd, C. eds, (1978), *Alternatives to Piaget, Critical Essays on the Theory*, London, Academic Press.

Shneiderman, B. Human Interface, The Next Accomplishment For Computers in: *Perspective (NCR),* Vol. 3, No. 4 University of Maryland Human-Computer Interaction Laboratory.

Shneiderman, B. (1991), Education by Engagement and Construction: A Strategic Education Initiative for a Multi-media Renewal of American Education in: *Sociomedia, Multimedia, Hypermedia, and the Social Construction of Knowledge*, Ed. Barret, E., The MIT Press, Cambridge, MA.

Shneiderman, B. (1993), Engagement and Construction: Educational Strategies for the Post-TV Era, *Journal of Computing in Higher Education*, Vol. 4 No. 2, pp. 106-116.

Somekh, B. (1986), In: Schostak, J. (1988), *Breaking into the Curriculum: the Impact of Information Technology on Schooling*, London, Methuen.

Somekh, B., Davis, N. (1991), Toward a Pedagogy for Information Technology, *The Curriculum Journal* Vol. 2, No. 2, pp. 153-170

Somekh, B., Davis, N. (eds.), (1997), *Using Information Technology Effectively in Teaching and Learning, Studies in Pre-service and In-service Teacher Education*, London, Routledge.

Stevenson, J. (1998), Performance of the Cognitive Holding Power Questionnaire in School*, Learning and Instruction*, Vol. 8, No. 5, pp. 393-411.

Sussex University, A study of more than 20 teleworkers and their families, *Science and Policy Research Unit, 1994*.

Turkle, S. (1995), *Life on the Screen, Identity in the Age of the Internet*, New York, Simon and Schuster.

Underwood, J., Underwood, G. (1990), *Computers and Learning: Helping children acquire thinking skills*, Oxford, Basil Blackwell.

Veblen, T. (1899), *The Theory of the Leisure Class*, New York, Macmillan.

Virilio, P. (1995), Red Alert in Cyberspace From: *Le Monde Diplomatique* August 1995, Translated in: *Radical Philosophy* 74, December 1995, London Central Books.

Vygotsky, L.S. (1962), *Thought and Language*, Cambridge, MIT Press.

Watson, D. (1987), *Developing CAL: Computers in the Curriculum*, London, Harper and Rowe.

Watson, D. (1993), *IMPACT – An Evaluation of the IMPACT of the Information Technology on Children's Achievements in Primary and Secondary Schools*, London, Kings College.

Wertsch, J.V. (1998) *Mind as Action*, Oxford, Oxford University Press.

Whorf, B.L. (1956) *Language, Thought and Reality*, Cambridge, MIT Press.

Winograd, T., Flores, F. (1988) *Understanding Computers and Cognition*, Reading, MA, Addison Wesley.