Technology and the Education Factory

The regular overhaul of the United Kingdom education system brings to the surface many of the tensions of society itself. The conflation of international school rankings, economic decline and the prospect of dominance by what used to be described as the emerging economies has spurred Government in 2012 to declare the need for schools to teach Computing, rather than the previously-prescribed lowly ICT. The assumption seems to be that the teaching workforce is full of eager Computing specialists who are all too ready to ditch the low-level Office skills they were required to teach and adapt to new examination syllabuses.

This conveniently overlooks that fact that teacher professional development in ICT has, for more than twenty years, been more than problematic. During a survey on ICT CPD undertaken as part of research for Becta in 2010 one CPD provider commented that those who knew (about ICT) were doing it themselves through their personal learning networks (PLNs) themselves. Those who didn't have a clue about ICT didn't even know what they needed to learn, and were not getting the experience they needed to make choices. Things have not changed since then, so it will be interesting to observe the endogenous growth and development of Computing specialists for schools.

Be that as it may, the current efflorescence of the white-hot heat of the technological revolution, with its twenty-year cycles, caused me to disinter some of my work from some fifteen years ago, when there were similar concerns being voiced about the inability of schools to prepare students to use ICT.

And we go back to another time, and other worlds ...

During the 1990s I worked in an 11-18 comprehensive school in West Yorkshire with 1800 students. I was particularly interested in the ways in which the students used computers for a range of activities, none of which they had necessarily been taught. In fact, teaching across the school was patchy at best, with the majority of exposure to computers being subject-specific: applications designed to teach particular elements of the curriculum. I was reminded of my experiences some years before, when I worked in Saudi Arabia, 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.

> *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)

I wondered whether I would be able to see the same impact on learning, work and behaviour that I had witnessed during my time in Saudi Arabia, so from 1994 I conducted an annual survey across the whole of the school, and repeated the process for the next five years. The first survey showed a significant number of students using a computer at home - 58%. This number increased with every survey, so that by the 1999 survey ownership ranged from 77% in Year 7 to 85% in Year 12/13. 81% of the school had a personal computer at home that they used for work, information and leisure.

My initial hypothesis was that the most immediately apparent impact of computers on student work, the ability to handle, manipulate and present data within documents, would be the factors that would have increased. I had collected some ten years of student work for analysis, and I had almost five thousand responses to surveys about computer use collected over a four-year period. The rapid take-up of computers by students had certainly changed what they did; it had changed the ways in which they talked about computers and work.

So, what about their teachers?

Surveys into student computer use had been extended to teaching staff on each occasion. Teacher use of computers had consistently been below that of students, both in terms of the range of applications and the amount of time spent using computers. Factors leading to this were identified as the problems of integrating IT activities into the prescriptions of the National Curriculum and difficulties in managing the learning environment of a computer-resourced classroom. The range of computer systems cited by teachers were predominantly those to be found in schools but when ownership of computers was examined, many teachers commented on their high cost as a proportion of taxed income. There was also an unwillingness on the part of some teachers to purchase something that would only lead to them producing more work in their own time. Despite these reservations most teachers expressed the view that there were benefits for students using them.

Over the next two years I extended the survey beyond the staff at the school to identify wider teacher ownership of, and attitudes towards, computers and their use for schoolwork. A sample of teachers in the local authority was surveyed to identify their perception of the impact of computers on students' work. The survey was carried out at two schools and an L.E.A. professional development centre.

Teachers were asked whether they had a home computer and, if so, what type it was and the purpose for which it was used. Although some 85% of teachers said that they had a computer at home the ownership pattern was extremely varied.

PC	Acorn	BBC	Mac	Amiga	Atari	Psion
58%	20%	1.7%	3.4%	0.9%	0.9%	0.9%

Although, by 1997, a PC running a Windows operating system had become the de facto standard for personal computing, it is significant than 20% of teachers owned and used an Acorn computer: either an Archimedes, or the older BBC Acorn. Many schools within the local authority were still equipped with Acorn Archimedes, and their forerunners. Very few schools, on the other hand, used Apple Macintosh computers, compared with the art colleges.

When teachers were asked what they felt had been the main impact of computers on student work the majority of the answers - 37% - focused on presentation, the surface gloss of the work. Other significant impacts were identified as motivation (17%) and CD-ROM research (10%), at a time when very few schools provided students with Internet access. There then followed a fairly random list of factors that teachers thought had an impact on student work: word-processing; the production of project work documents; Computer Literacy; Control Technology; Integration of syllabus topics; understanding of concepts; the use of the computer as an extra tool; drafting to improve content; statistical modelling and, finally, the possibility of a variety of teaching styles. Despite the confused responses 80% of teachers surveyed felt that student work was improved by the use of computers.

Given the initial teacher responses it came as no surprise when teachers said that the aspects of student work that had been most improved were legibility (66%); the organisation of work (56%); spelling (41%); and the integration of text, tables and charts (41%).

The teachers' perceptions, therefore, were focused on presentation of the work which students generate, and the ways in which its elements are integrated. The predominance of word-processing in computer uses cited by staff respondents (71%) would correlate with this. If word-processing is the application most familiar to teachers, then these are the effects that will be most readily apparent when student work is assessed. The illocutionary message is that word-processed work, which is legible and well-organised will be rewarded more highly than hand-written work.

Teachers were then asked whether they could quantify the improvement in terms of marks. Almost 44% of teachers felt that the use of computers improved work by up to 15%, and the student cohort most affected was Key Stage 4 – those taking GCSE. 23% of teachers felt that work was improved by up to 25%.

Some teachers focused on the negative impact of computers, and cited the problem of 'Computer as scapegoat', in that students were able to use the computer as a reason for failing to submit work to deadlines. The limitations imposed by inadequate word-processing skills were also seen as a problem, together with an apparent lack of sequencing of work by some students. The use of inappropriate charts in documents was also seen as one of the negative affects produced by computers on students' work, where the focus was often on presentation, rather than content. One teacher commented that computers did not "…help…handwriting skills. Poor handwriting is not improved."

The significance of these comments lies more in what they reveal about the level of teacher intervention in students' work: teachers see themselves as judges of a finished product that is a reflection of a student's skills and abilities. What is required is dialogue between teacher and student during the process, rather than final comment on the finished product.

Among other negative factors identified were the transfer of work away from school for those who had a home PC, and the accompanying disadvantage of those without home facilities. Those who were reliant on school machines took a long time to complete a task: "…they spend a long time writing up assignments." There was a tendency to view word-processing as a variant of typewriting, in that a student's work receives its final polish through the medium of the computer.

When teachers were asked to indicate uses to which they put computers at school, for personal and curricular outcomes the majority of teachers focused on IT activities that produced short-term, measurable outcomes. These activities were also those undertaken at home, and ones with which the teachers themselves were most familiar.

Word processing was referred to as *'typing'* by most teacher respondents. This was the application used by most teachers on their home computers.

The focus on short-term, measurable outcomes carried across into the way in which teachers perceived the utility of what students did with computers.

When teachers were asked what impact they thought that computers had on students' work, their responses fell into three main categories. These can be grouped as transactional, cognitive or affective.

Not surprisingly, the most frequently cited set of responses fall into the category of transactional factors. This correlates with the most frequently cited curricular applications: word processing, databases, charts and spreadsheets. Presentation is the most visible factor when teachers assess student work. Many students recognise this: when they were asked how they feel computers have improved their work many of them referred to its more 'professional' look.

Almost half of the teachers surveyed (43.6%) felt that work was improved by up to 15%.

Nearly one quarter (22.6%) felt that work was improved by up to 25%.

It was factors such as legibility, organisation of work, spelling, integration of text and tables and overall presentation that differentiate student work within mark schemes.

These outcomes were based on recognisable IT skills. Even teachers who did not use computers were able to identify these factors as contributing to the overall quality of a piece of work. In terms of a Uses and Gratifications taxonomy, most of the teachers were grounded at the level of **Personal Identity: Value Reinforcement**.

The implications of this were clear. Teachers who did not teach their students how to use information technology to produce their work were effectively disadvantaging them. Those students would not score as highly when the work was assessed.

Schools that failed to provide skills input and computer access for students who did not have a machine at home were compounding the disadvantage.

Teachers in the survey had a limited perception of cognitive factors being improved by computer use. Eight items received mention: integration of syllabus topics; understanding of concepts; computer as a tool;

drafting to improve content; statistical modelling, variety of teaching styles; grammatical structures and increased problem-solving skills. An improvement in the use of grammatical structures was the most frequently cited benefit (10%), and it could be argued that the provision of grammar checking tools in word-processors were responsible for that benefit. There was no suggestion that this gain transferred itself into other writing environments.

Teachers' perception of the cognitive benefits of computer use, then, tended to be limited, subject specific and measured in terms of the curriculum element for which the teacher has responsibility. There was no overview of ways in which students use computers for work across the curriculum. There was no evaluation of overall cognitive benefits for students.

In terms of affective factors 17% of teachers felt that computers improved motivation. This would suggest that the active element in working with computers was a motivator for those students who perceived the experience of being taught as essentially passive. The contribution of computer use to the enhancement of affective factors was implicit within many of the comments made by teachers. The increased motivation of many students when they were able to work on computers was seen as crucial to the improvement of the work. In the same way in which students were able to invoke the computer as scapegoat, this same process enabled their teachers to take a more impersonal, functional view of work. Changing text and reprinting work is easy: this encourages re-drafting of work and increases output.

Teacher perspectives:

- 62% of the sample stated that they used computers in the curriculum for word-processing, although no frequency of use was cited. One survey of more than 3,400 teachers (Keele University, 1996) cited 70% as using the computers 'very infrequently'. Another found that four out of five teachers claimed that they were not familiar enough with computers to make full use of them in schools (Technology Colleges Trust, 1998). Although 43% of UK schools might have had computers connected to the Internet, only one third of these provided their pupils with Internet access. (British Educational Suppliers Association, 1998.)

- The teachers' main use of a computer was for word-processing (71%). This activity was, however, often cited as 'typing'.

- When teachers own a PC the site of production for work-related documents moves from school to home - as happens with many students.

What computers don't do

The concerns that teachers in the survey expressed about the use of computers in schools were not, in fact, about computers per se. The concerns were about other aspects of the curriculum that computer use highlighted. Teachers felt that computers failed to do a number of things.

They did not prevent students from evading responsibility: students were able to invoke technical failure, networking problems and lack of access as plausible reasons to avoid deadlines. Many students failed to make sure that they had adequate word-processing skills before they produced a piece of work, which meant that those teachers who themselves lacked those skills were unable to help them. The work itself took longer to produce, students often failed to save their work appropriately and had problems retrieving it at a later date.

Many students failed to use appropriate charts when converting data. Their lack of understanding meant that, whilst the software could easily convert data into a graphical format, the students were unable to choose the most appropriate format. Often the criteria for selecting a chart type were the colours and shapes on the screen.

Many teachers felt that computer use prevented many students from improving their handwriting skills, whilst at the same time they often spending too much time 'writing up' assignments.

The use of CD-ROMS posed problems for some teachers: students would unselectively print out passages from reference disks as their response to an assignment, whilst other students would steal the CD-ROMS.

Computer Assisted Learning (CAL) and Computer Assisted Language Learning programs (CALL) suffered when students used games-playing techniques and strategies with educational computer programs. These students saw the object of the exercise as 'winning' and achieving a high score, rather than using the program to reinforce learning. It may well be argued that despite this perception on the part of students, learning did take place, albeit at an implicit level. The significance of the reaction, however, is that it would appear to produce behavioural effects at variance with those expected in classroom learning.

One problem that teachers identified was that many students with a PC of their own preferred to work at home, rather than at school. This confirms many of the observations made by students themselves during the surveys. The reasons given by such students related to the amount of control which they had over their work environment at home, rather than at school. Whilst many of the examples referred to perceived limitations of school hardware and software, the amount of time which students could devote to work at home was also a factor.

Students without a home PC were doubly disadvantaged in these circumstances. First, they were dependent on school ICT resources if they needed to produce IT-based work. They had far less time which they could devote to its production, and far less freedom to experiment with a range of possible approaches. Second, given that in many schools the number of available computers is less than the number of pupils in the class, teachers allocate computers to those without one at home. This requires a range of tasks to be set to accommodate those who have computers at home: those dependent on school computers miss this additional work.

What the use of computers by students does, however, is to throw these issues into relief. They are central to the ways in which students learn, and are taught. They provide a focus for the ways in which teachers assess work.

The most significant issue, however, was the way in which productive capital, cultural capital, symbolic capital and educational capital were converging. Computers had become the site of conflict on which the class battles of the information age were being fought. Changes in employment patterns during the previous decade had resulted in a growth of service-sector jobs, many of which required ICT capability. A flexible labour market required transferable key skills such as communication, application of number, information technology, problem solving, working with others and improving one's own learning and performance. Dependence on limited institutional resources, education and training did little for students whose only asset was labour.

What did this say about teachers?

The most significant and depressing aspect of the results was the acceptance, on the part of teachers, of the disparity between the processes and abilities of students and teachers in using computers, and the conceptual gap with Information and Communications Technologies. Many teachers assumed that, because students could do things with computers, they knew how to do them and why they did them. Further, there was an assumption on the part of many teachers that there was one way of doing something – the 'right' way. They were privileging their students as 'experts' and destabilising the ecology of the classroom.

This was matched by an unwillingness by teachers to take charge of the technology for themselves. In part this was because many secondary school teachers still felt that ICT was a separate subject and was not part of their curriculum responsibilities. In part it was also due to the sense of fatigue felt by many teachers who struggled to keep pace with the remorseless flow of curriculum change and documentation visited upon schools.

In addition, a significant number of teachers felt that the disadvantage of those without access to a PC at home could be ameliorated by creating a computer-free zone in their classroom. A sub-text to this was the low level of ownership among teachers themselves. The purchase of a new computer represented a considerable proportion of their disposable income. Those teachers who used computers both at school and home, for a range of tasks, were more likely to be enthusiastic about using ICT in innovative ways within the curriculum. This was supported by the findings of Preston, Cox and Cox (2000) for the Teacher Training Agency. The Computers for Teachers scheme, introduced in January 2000, was an attempt to meet this need. A significant number of teachers, however, failed to take up the scheme and viewed it with suspicion.

What did it say about students?

As I looked at the results of the surveys, talked to students and felt the currents shifting in my own classes I was aware that I may have been looking in the wrong direction; trying to make sense of the wrong signs. I was looking at what the students were producing, expecting to see an increase in the number of transactional reports and the quantity of data being analysed. I realised that the greatest change was in the way these objects were being produced, and the changing student attitudes towards them. Students could do things with computers, but there was no guarantee that they knew how to do them in a systematic way, or could repeat their work. What was uncertain was whether or not students possessed a mental model of the processes in the systems they were using (Hagmann, Mayer and Nenniger, 1998). Knowing why they did them, as a series of routines that formed part of operational procedures, was difficult to establish. Part of this difficulty may well have been the difference between being able to do something, and analysing and describing the process. However, many students felt that they worked intuitively, and that their computer 'made it work'.

Students knew that there were a number of ways in which tasks could be undertaken: their computers could achieve the same outcome through a number of routines. Their teachers, however, often assumed that there was one way of doing something. The authority of the teacher was being further undermined.

Multi-tasking cyborgs: Implications

The volume of evidence that was collected suggested that an initial hypothesis, that students would produce transactional and analytical work in greater quantity, was only true for those subjects which expected it: Business Studies, Economics, Geography, some Science projects and Technology. Perhaps the most significant factor, however, was the way in which these objects were produced. Many students were producing work without feeling that they needed to master programs and operating systems beforehand. They were, in a very real sense, ‘just-in-time’ workers. Teachers supplied the tasks; they supplied the ideas; the computer made it all work.

Working with computers

The surveys of student computer use from 1995 onwards showed the extent to which a significant number of students used personal computers. Student comments indicated the range of activities for which these machines were used. Indeed, many students commented that they regarded schoolwork, learning and computers as synonymous. Previous reference has been made to these comments. Their significance, however, is such that they bear repeating again.

Now I use my computer for all the work I do apart from Maths and things like that. I can draw on my computer, make music, listen to music, write stories, look up words to find a meaning for it like a dictionary, print out any work I want for homework. I think it makes homework a lot easier because of all the different programs.

(Girl, Year 9.)

This student had created a working environment with her computer, which provided her with the tools and support necessary for the work she produced to be a reflection of her capabilities. Her abilities were augmented and enhanced by the tools which she used.

Computers can make homework need a lot more time, even if you’re very good at using them, because you end up spending a lot of time tweaking your work. The end product can look very good, especially with expert use. Spellchecks and automatic language aids such as Thesaurus help your writing. Computers with reference software, such as “Encarta” are great for research. AmiPro2 is the best word processor/d.t.p. program in the world. Apart from AmiPro3. You can also sharpen up your brains playing games such as Tetris and Doom.

(Boy, Year 10)

The judgements made by this boy focused on what was done - the homework, and the fact that more time was spent on it - and how it was done. The awareness of ‘expert use’ of software and its built-in tools was that it enhanced the product. The sub-text was that the user was enhanced: ‘You can also sharpen up your brains …’ The computer-human interface was part of his discourse.

I had my first computer when I was six. I’ve used one ever since.

(Boy, Year 12)

The human-computer interaction described here had been a constant theme in the surveys conducted during the period of this study. As the technology became more powerful, flexible and sophisticated, so it had become more open to being customised by student users. Individual needs and circumstances had enabled a constantly evolving setup and use of the equipment. Students regarded the layout and look of the

Graphical User Interface as both a reflection of, and extension to, their personality. In this sense then, if no other, they had taken on attributes of cyborgs.

'Cyborgs'

The image of the cyborg as a super-human combination of the mortal and technology has been part of popular culture for more than thirty years. The term 'cyborg' was initially coined to describe human enhancement: a man-machine system, or hybrid, that would be necessary to survive in, and adapt to, the extra-terrestrial environments of space flight. Routine checks and monitoring would be undertaken automatically, so that the human would be free to create, think, feel and explore. (Clynes and Kline, 1960) Cyborgs can also be seen as the tangled networks of meat, metal and technologies that we have become: creatures in a world that is post-gender (Haraway, 1985).

The integration with technology enables humans to transcend their corporeal limitations. This is true for individuals fitted with prosthetic limbs; with heart pacemakers or whose use of pharmaceuticals enables them to overcome bodily malfunction. Science fiction fantasies on television and film, such as The Six Million Dollar Man, Terminator or Robocop, provide a leitmotif for the concerns of our age in much the same way as Frankenstein served for the Enlightenment. Cyborgs, then, provide a route for us to stand aside from the limitations imposed on our bodies by restrictions of race, gender, class and socio-economic status.

The students in this study can be regarded as having integrated with computer technology because the operations which they undertook using the machines have been internalised. That is to say, the programs and routines that they used, they used intuitively. The hardware and the software which they used is seen as a means to an end. They were a tool, a vehicle for combining motor skills, language, images and symbolic manipulation through practical activities. They were enabled to stand aside from the limitations imposed on them as subordinates in the school system

So computers were the tool, the vehicle for combining motor skills, language, images and symbolic manipulation through practical activities. These practical activities reflect a series of often complex thought processes. They represent a cultural tool that enables the mediation of thought (Wertsch, 1998). The technology enabled these processes to be amplified and developed in ways which reflected the integration of technology. Fast multi-tasking had become one indicator of this integration. The students may fail to reflect media images of Cyborgs such as Robocop or the Terminator, but their behaviour and artefacts, products of that behaviour, suggested that the myth was manifesting itself. Computing technology had transformed student expectation of what was possible: the limit was perceived to be that of the technology itself.

Statements made by students throughout the surveys assert that learning to use their computers is a by-product of using them: they are 'learning how', rather than 'learning about': the learning is how to achieve what the student wants to achieve.

Cyberspace

'Cyberspace' is a term that originated in science fiction to describe virtual worlds. Its most common use, however, is to describe a range of aspects of everyday life connected with computers and the Internet. The use of electronic mail, Internet chat rooms and discussion groups and participation in virtual communities have all contributed to a culture in which simulation is accepted as part of the experience which constitutes the post-modern condition. Electronic data transmission enables ‘cashless’ economies and purchases; online games provide challenges against opponents whose identity exists only on the screen.

An alternative interpretation of cyberspace is that of an ideology, for those who see themselves as transcending the limitations imposed on them by the society in which they live (Virilio, 1995). This concept of cyberspace is seen as a way of being in contact with a global community in which links can be established with those who share the same interests or apparently think in the same way. Those who see themselves as part of cyberspace have a sense of power, endowed by the exclusivity of the skills and concepts shared by the global community. They regard themselves as the cutting edge of technology. This power is reinforced by the anonymity of cyberspace and the apparent lack of temporal responsibility and accountability.

The individuals who were empowered by possession of computer communications saw themselves as technological superheroes, moving from one part of the globe to another in nanoseconds. Access to information (whether real or imagined) is what differentiates technoheroes - Virilio’s term for what many young people consider to be cyborgs - from the rest of humanity. The structures of inequality were compounded by the continual and rapid updating of hardware, software and the skills and concepts with which they are associated.

When these changes were coupled with increased investment in new communications technologies by business and industry the substitution of the economic factors of labour by capital further disenfranchised those who lacked the skills needed to exploit new possibilities.

Technoheroes reifyed this constant advance: the latest upgrades, the latest skills and the latest vocabulary are all essential to staying ahead: having the edge needed to ride the InfoWave. Students adopted these rapid technical developments as another facet of their perception that life is a process of constant change.

Computers are the future they are quick and easy.

Boy, Year 9.

This constant change can be can be attributed to the dramatic fall in the price of computer memory over the years. (This smooth progression conveniently ignores the spikes caused by surges in demand, earthquakes in Taiwan, floods in Thailand and other glitches of globalisation.) The sub-text is the dramatic increase in the demand for memory and processing power by software packages. The concept of ‘more for your money’ drives people to upgrade their machines with increasing regularity.

Computers are expensive but if you didn’t have one you probably would be degraded because of it in later life.

Boy, Year 10.

The comment used by this student in his letter was reflected by a number of others, who saw computers as creating added value in their schoolwork, which would then lead to greater opportunities for progression. It was perhaps predicated on the post-industrial nature of Yorkshire, in which employment in mining, heavy industries and manufacturing had been in steady decline for the previous twenty five years. The biggest employment area was in the service sector, more specifically in the banking, insurance and financial sectors.

Computers and enjoyment

Many students commented that they enjoyed working on the computer. A number described it as 'fun'. Whilst this may, in part, have been due to the fact that they could listen to music and play games whilst they were working, other factors should be taken into account to explain the element of 'fun' and enjoyment.

The focus of many consumer electronic technologies has been on ludic elements: that is to say, aspects of games and play. Early surveys of student computer use revealed an ambiguity as to what constituted a computer, especially among younger students. Many mentioned games consoles or hand-held electronic games. Commodore Amiga computers had been purchased in the hope that they would offer both a platform for sophisticated games playing and a tool for schoolwork.

These elements of play have long been incorporated into mainstream applications, most specifically as icons, prompts and Wizards. Indeed, many programs offer animated initial screens as a way into the content. Whilst these were first targeted at younger users (as in Microsoft's Creative Writer and Creative Artist) they spread to other programs (for example, that for Epson Stylus colour printers). The development of the Graphical User Interface (GUI) presented the computer user with an interface that initially simulated the space on a desktop. The user could then customise the space by installing short-cuts to favourite programs and document folders, personalising the screen-savers: in short, making the machine a reflection of the user's personality.

The GUI also presented an opaque interface with the computer: there was no necessity to learn sets of commands and then use these to instruct the machine. The user pointed at 'objects' and clicked to activate them: on-screen Wizards supplied questions, prompts and instructions to enable users to achieve their purpose. Students could point and click at programs, documents and objects; switch from one to another; perform one task whilst another was running in the background.

Multi-tasking

The conventional understanding of multi-tasking is that of a computer running a number of programs simultaneously. One program will run in the foreground (a word-processor), whilst others run in the background - a print manager printing a number of documents; a database indexing a datafile. Other programs will foreground themselves: email announcements; error messages from the operating system; 'paper out' reports from the print manager. Other instances of multi-tasking occur when students have a number of windows open on the screen and switch from one document to another as they are working.

Comments from students in previous sections have illustrated their use of multi-tasking capabilities whilst they work with their machines. One way in which students switch from one task to another is the combination of the ALT/TAB keys. This enables a number of programs to run and the students to move between them. Observation suggests four main ways in which this technique is used.

The most frequently observed use of this technique is when students switch between programs and applications as part of the task - with a spreadsheet and a word-processor; a web page, a word-processor and a presentation program or between a document and a CD-ROM.

Another use is cited during homework, particularly coursework for GCSE. Students will have a number of tasks open, and switch between them as they become tired, or become stuck.

The third use is an extension of toggling between programs, where they will switch from the tasks to a game, and then back again. These uses all demonstrate the way in which students move from full engagement with the task (and learning) to a state of reflection. Whilst this reflection may take place during a period of 'tinkering' with the text, by changing fonts and margins, running the spell-check and other utilities, it also takes place whilst the student engages with other tasks, or plays a game.

The final use of switching is between licit and illicit activities, when students are expected to be on task but occupy themselves instead with the maintenance of their web site, speculative surfing or with interactive chat rooms. The most ingenious collective use of the ALT/TAB facility was with a class which was being taught Excel spreadsheet routines. The teacher was demonstrating the program and the tasks the students were expected to undertake. The students were using their own chat program to carry on 'conversations' totally unrelated to the lesson. When the teacher asked a question, or moved around the room the student would ALT/TAB from the chat to the spreadsheet (Abbott, 1998). It might be argued that multi-tasking is merely the material form of an activity that has always taken place. What the computer offers to the user, however, is the prospect of simultaneity, however much of a simulation that might be. Simultaneity becomes embodied, both within the computer and its user. As Gardner has commented,

The invention of the computer has provided a powerful if ever-changing model of cognition and an invaluable tool in simulation, data analysis and conceptualisation of the human Mind.

Gardner (1993, p.41.)

This use of the computer as a metaphor for the human Mind and cognition is one that is explored in the next section.

Learning styles

Learning styles are the different ways in which individuals think and learn. These become formalised as expectations and behaviour, which the individual then brings to the task of learning. The stages of learning can be separated into three broad areas: cognition, the acquisition of knowledge; conceptualisation, the processing of knowledge and the affective factors related to these. The focus is therefore on the process of learning.

Kolb (1984) saw learning as an active process. Its stages formed a continuum, from concrete experience: (involvement); reflective observation, watching others or developing observations about one's own experience; through abstract conceptualization: the creation of theories to explain one's observations; to active experimentation, using theories to solve problems and make decisions.

Gardner (1983) identified different types of learning, particularly those characterised as 'know-how' and 'know that'. From that he defined 'multiple intelligences', to describe the different ways (and combinations of ways) in which individuals learn. Learning can be seen as 'playing' with different capabilities: the verbal/linguistic; logical/mathematical; visual/spatial; musical/rhythmic; bodily/kinesthetic; social/interpersonal and personal. This perspective provides an immediate rationale for the use of computers by young people: the combination of play elements – the ludic – the use of language as part of the process, together with visual stimulus, means that the computer provides a focus for different types of learning.

Some, however, assume that the young learner - a child - is not the same as a mature learner - an adult, and that the learning styles must be different (Knowles, 1970). Adult learners are often characterised as autonomous and self-directed; goal oriented; problem centred and needing to know why the learning is taking place. Adults are seen as practical problem solvers, able to draw on accumulated life experience. The young learner, the child, is assumed to possess few, if any, of these characteristics. Many of the assumptions implicit in classroom praxis are predicated on this dichotomy.

Learning strategies for adult learners have been grouped in binary terms by Felder and Soloman (1998). They have re-worked Gardner's concept of multiple intelligences into descriptions of active and reflective learners; sensing and intuitive learners; visual and verbal learners and sequential and global learners. Indeed, Gardner comments that

…intuitive theories remain as pre-potent ways of knowing and are likely to re-emerge with full force once the person leaves a scholastic milieu.

(1993, p.86)

The point is made that computers are artefacts that reinforce intuitive understanding and ways of knowing and learning. This perspective places computers as tools, external to, although enhancing, cognitive processes and development.

Multi-tasking and learning

This research indicated the diversity of approaches utilised by students when working with computers. Further, the extent to which students used them for work illustrated the ways in which the computers were not simply artefacts that reinforced intuitive understanding and ways of knowing, but rather an integration with the understanding and the thought processes. Knowledge was therefore constructed by the learner, as part of the work process.

If the picture of an adult learner is one of someone autonomous and self-directed; goal oriented; problem-centred and needing to know why the learning is taking place; a practical problem solver, able to draw on accumulated life experience, how is that different from the way in which young (child) learners work with their computers? The opportunities for learning commonly applied to adult learners, those of case studies, role play, simulations and self evaluation are precisely those through which younger students learn when using their computers.

Multi-tasking cyborgs?

What differentiates computers from previous technology to which students have had access, such as cassette recorders, calculators or VCR machines is that both the software and hardware offer a seemingly endless range of possibilities. Whether the student is an active or reflective learner; a sensing or intuitive individual; a visual or verbal learner and sequential or global learners, the way in which the computer is used will reflect that. The active, visual, intuitive and global nature of multi-tasking is likely to develop those particular styles of learning. Conventional educational pedagogy has been superceded by learners who have constructed the active, goal-directed learning patterns previously associated with adults. The integration of computers with the individual's understanding and thought processes will create new ways of thinking.

The cyborg of Clynes and Kline constructs itself with every new piece of work. The student and her computer form the man-machine system, the hybrid, the cyborg. The operating system and the programs perform the routine checks and monitoring, checking, correcting, formatting, saving the work. The student is set free from her limitations, to create, to think and to explore a range of possibilities.

Just as long as she is one of the 80% with access to a computer at home.

Plus Ça Change?

By the time I had finished this research I felt that I had identified a pattern of working that a significant number of students were adopting. I had almost five thousand responses to surveys over a four-year period. The problem was whether the themes emerging from student responses were simply descriptions of behaviour, or whether there was a more fundamental change. In part, it was the problem of the Uses and Gratifications approach to data collection, and the tracking of responses in percentage terms. What I still lacked was the evidence that the students as cyborgs were using their computers as the tools to set them free.

I had assumed that the most immediately apparent impact of computers on student work, the ability to handle, manipulate and present data within documents, would be the factors that would have increased. I had some ten years of student work to analyse. Whilst my assumption was true for the first three or four years of the work sample, there was no significant increase in the evidence beyond this point.

It was as if those students whose approach to work was analytical and systematic were able to produce more of it, and those whose limitations held them back from producing this type of work had been facilitated by computers. After that, more students were using computers, but for different purposes, in different ways.

The rapid take-up of computers by students had certainly changed what they did; it had changed the ways in which they talked about computers and work. What these students were demonstrating was the process of Bricolage (Levi Strauss, 1962).

It's now recognised by the term 'Mash-Up'.

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