Lessons from the Great Underground Empire: Pedagogy, Computers and False Dawn

Stewart Martin

Faculty of Education, University of Hull, UK
stewart.martin@hull.ac.uk

Abstract. The educational use of computers in the UK coincided with growing tensions between educators and government policy. This led to the imposition of a National Curriculum and policy that took scant account of research evidence or the views of professional educators. As a result of this unhappy coincidence, the UK failed to take early advantage of the educational benefits offered by this technology. The exploitation of the unique affordances of computers have seen a false dawn and dashed hopes but, slowly, a body of research has emerged that is now starting to identify where we should look and what we should do. However, the necessary changes would fundamentally alter the roles of teacher and learner within the educational system as well as government policy and this may go some way to explain government reluctance and the systemic inertia in the UK and elsewhere.

Keywords: computers, education, teaching, pedagogy, computer games, government policy, cognitive load theory, learning styles.

1 Introduction

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West of House.
You are standing in an open field west of a white
house, with a boarded front door.
There is a small mailbox here.
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Although many people today will never have heard of it, this is the opening text of what is arguably one of the most iconic pieces of interactive computer software ever written - and is the place where my journey into the use of computers in education began.

The software in question is the computer-based adventure-game trilogy *Zork!*, which was written in 1977 on a 'mainframe' computer by Tim Anderson, Marc Blank, Bruce Daniels and Dave Lebling, who were members of the Dynamic Modelling Group at the Massachusetts Institute of Technology [1]. Published in 1980 by the American software company Infocom, *Zork!* was part of a genre of digital interactive fiction which ran on the then emerging market of commercial computers aimed at the home. Unlike today's computer software which depends upon powerful

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multimedia machines to function, *Zork!* ran on much more modest technology and featured only white text on black backgrounds; it contained no colour, graphics, animation or sound effects. In the context of *Zork!,* 'interaction' therefore comprised of the user repeatedly responding to the text which appeared on the screen by typing in words at the keyboard and observing the software's response. As one commentator of the time noted:

> *"*Zork *is all text - that means no graphics. None are needed. The authors have not skimped on the vividly detailed descriptions of each location; descriptions to which not even Atari graphics could do complete justice." [51]*

Between 1980 and 1984 I worked as Senior Teacher at a large secondary school in Maidstone, a county town in southern England in Kent, in the UK. My main teaching role was in the English Department and as part of this I had a number of classes of low achieving students, comprised mostly of boys, who were preparing to take external public examinations. The low levels of educational attainment in that particular school during the 1980s were not uncommon, as educational achievement and aspirations in many schools around Maidstone at this time were significantly below national averages.

During this period the UK Government, under both Labour and then Conservative leadership, launched and nurtured the Microelectronics Education Programme (MEP), which ran from 1980 until 1986. The programme was managed by the newly formed Council for Educational Technology and, following the involvement of the Department of Trade and Industry in 1982, saw the introduction of a computer into every school in England. The machines provided for this purpose were Research Machines (380Z or 'Nimbus' machines), BBC 'Acorn' computers and also the Sinclair ZX Spectrum; the latter being most commonly used for control projects, such as teaching children how electronic switches in circuits or traffic lights worked.

At this time one read in much of the literature circulated to schools that the objective of the MEP was to promote the study of microelectronics and its effects, and to encourage the use of this technology as an aid to teaching and learning. When our school's computer arrived (and it was just one single computer), the Head Teacher was disposed to offer it to the Physics department for dismantling and study as part of the study of microelectronics but was persuaded by me to keep it in one piece and allow the English Department to use it as an aid to teaching and learning instead.

Initially this single Research Machines 380Z computer in my classroom was used for word processing with single students or small groups and when it was eventually supplemented by several additional 'Nimbus' machines this work was extended to larger groups, although the eight machines available still made it difficult for students to be allocated to their own computer and forced students in classes to work together in groups. It became clear later that this restricted availability proved to be an opportunity in disguise.

Whilst the curriculum work done by students with these machines was interesting and unusual, their use seemed to appeal mostly to academically able students who could take advantage of word processing software's ability to format and edit text so as to improve its clarity of expression, eloquence or persuasive power. This suggested

that the educational usefulness of computers might largely be related to a student's academic ability in a given subject but it seemed equally possible that the technology simply appealed to those students who liked to learn in a particular way because the available software offered opportunities for working in a manner that somehow suited their preferences. As the technology at that time was limited in its ability to present content using different media, styles or formats, it seemed likely that if differences in these things were important for individual student engagement and learning then only those learners for whom that limited range of presentational styles and formats was valuable would be strongly attracted to its use.

The affordances offered by the word processing software we used were insufficient to encourage the majority of my weaker students who were still struggling to master basic English expression, spelling and grammar; what was unclear was whether this was more to do with the difficulties they were experiencing with the subject content itself or because their preferences for learning in certain ways were not being very well catered for by the software, or whether the ways in which content was presented to learners made a significant difference to learning for all learners, or even whether these issues were all closely related.

2 Early Exploration

I became interested in discovering whether successful learning with computers was more likely to be about providing for each individual student's approach to learning (their habitual preferences for how they liked to learn, if such a thing existed) or about being able to present subject content in particular formats that were intrinsically more likely to lead to learning because of their structure and format. Although there was no computer software available at this time that would allow me to address these issues it was whilst I was thinking of how I might make this technology useful for my students that I came across the software which introduced this chapter. This software (*Zork!)* seemed to offer ways to begin exploring the questions that concerned me about using computers, because it required highly structured learning to engage with it successfully but did not impose particular ways or styles of learning on the user, although it did use a very limited text-based format for presenting content. I therefore anticipated that, like the word processing software we had used, it was likely to appeal only to a limited number of more able students.

Zork I: The Great Underground Empire is the first part of the *Zork!* trilogy and when one lunchtime I showed it to some of the students at my computer club it provoked considerable interest, I suspected largely due to its novelty. Amongst the group that day were some of my less able students who had wandered in whilst looking for something to do to avoid the rain outside and because of their earlier poor learning experience with word processing software it was this group's fascination with this software that particularly caught my attention.

Word got around of what was happening in the computer club. In response to the pleas from my students I allowed them limited access to *The Great Underground Empire* at the end of English class sessions, as a reward for hard work and task

completion. I anticipated that it would be useful in this regard only and it did seem to encourage my students, including my less able ones, to apply themselves more to class work although the latter continued to find the work itself difficult to remain engaged with, despite my best efforts to make the content more accessible and relevant.

However, over the following period of a week or so I noticed a pattern of behaviour emerging with regard to *Zork*! Whilst some students were content to use it alone, most seemed to prefer to wait until some of their classmates were also free and then explore it together. As I watched these students, it became clear that something quite interesting was going on.

Zork! has a limited vocabulary and is programmed to interact with the user in particular ways. The user assumes the role of an anonymous adventurer in this computer simulated fantasy world filled with scores of rooms, some containing traps, some containing puzzles. Hundreds of objects are scattered throughout this maze, some of which are valuable treasures, some of which are magical tools. At the heart of the program is a sophisticated piece of software (a parser) that breaks down what the user types on the keyboard into its component parts of speech, assigns each a function and establishes the syntactical relationship between each part. The software responds according to the output from the parser. Simply pressing only the 'Enter' key on the computer keyboard generates the response "I beg your pardon?", for example, so the user is required to think of what to say to the game's omniscient 'Dungeon Master' in order to access the environment in the game. When the user types words on the keyboard and then presses the 'Enter' key, the parser attempts to match the words and phrases typed (and to some extent their sequence) with its database of coded words and phrases and their relationships to known meanings. It then selects a response based on this analysis and presents this to the user on the computer screen whilst also selecting a 'move' from the software gaming engine to show the user (if relevant) the next section of, or solution to, the maze or puzzle.

Although not powerful by contemporary standards, the parser in *Zork!* is frequently able to present a reasonable if limited approximation to intelligent response that is at times quite amusing and uncannily human, thanks to the skill of the programmers. This interactive element within the software presented students with challenges and a typical encounter often went something like this (user-typed input in capitals):

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>OPEN DOOR
The door cannot be opened.
>GO WEST
Forest
This is a forest, with trees in all directions. To
the east, there appears to be sunlight.
>CLIMB TREE
There is no tree here suitable for climbing.
>ENTER FOREST
You hit your head against the forest as you
attempt this feat.
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>GO WEST
You would need a machete to go further west.
>GO NORTH
Clearing
You are in a clearing, with a forest surrounding
you on all sides. A path leads south.
On the ground is a pile of leaves.
>PICK UP LEAVES
In disturbing the pile of leaves, a grating is
revealed.
Taken.
>OPEN GRATING
The grating is locked.
>HELP
I don't know the word "help".
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I anticipated that, faced with this kind of interaction, most students would probably give up fairly quickly, especially as the early version of *Zork!* we used had no 'save game' feature, so when students came into the classroom and began a new session, or if their adventurer character 'died' in the game, as often happened, they always started right back at the beginning again, standing in an open field west of a white house, with its boarded front door.

To my surprise many of my students did not give up, however frustrating the difficulties became. Instead they began to discuss strategies with classmates and plan sequences of instructions. They began to explore the software's vocabulary and make lists of words and phrases it 'understood' and objects and actions it 'knew' about. Inventories of objects and their locations were developed, especially when it became clear that for many situations and places further into the environment certain objects needed to have been located and 'collected' beforehand because their possession by the adventurer was required to overcome obstacles, solve puzzles, open doors or pass barriers. They made maps of the underground terrain and recorded sequences of successful instructions, often in personal diaries or notebooks. They started to look up unfamiliar words in dictionaries, particularly when exploring vocabulary and wanting correct spellings.

The level of vocabulary and the complexity of description and of sentence structure tends to increase as users progress deeper into *Zork!* and the interaction becomes semantically richer [36]. The following is from a section a little further into *Zork!* than the previous extract and is typical:

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Living Room
You are in the Living Room. There is a door to the
east, a wooden door with strange gothic lettering
to the west, which appears to be nailed shut, and
a large oriental rug in the centre of the room.
There is a trophy case here.
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A battery-powered brass lantern is on the trophy
case. On hooks above the mantelpiece hangs an
elvish sword of great antiquity.
>TAKE ALL BUT RUG
Sword:
   Taken.
Lamp:
   Taken.
>READ
Read what?
>THE DOOR
The engravings translate to 'This space
intentionally left blank'
>LOOK UNDER RUG
Underneath the rug is a closed trap door.
>MOVE THE RUG
With a great effort, the rug is moved to one side
of the room.
With the rug moved, the dusty cover of a closed
trap-door appears.
>OPEN
Open what?
>DOOR
Which door should I open?
>THE TRAP DOOR
The door reluctantly opens to reveal a rickety
staircase descending into darkness.
>GO DOWN
It is pitch black. You are likely to be eaten by a
grue.
Your sword is glowing with a faint blue glow.
>WHAT'S A GRUE?
The grue is a sinister, lurking presence in the
dark places of the earth. Its favourite diet is
adventurers, but its insatiable appetite is
tempered by its fear of light. No grue has ever
been seen by the light of day, and few have
survived its fearsome jaws to tell the tale.
Your sword is glowing with a faint blue glow.
>TURN ON LAMP
The lamp is now on.
Cellar
You are in a dark and damp cellar with a narrow
passageway leading east, and a crawlway to the
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south. On the west is the bottom of a steep metal
ramp which is unclimbable.
The trap door crashes shut, and you hear someone
barring it.
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Faced with scenarios such as this, different groups began to collaborate to explore different regions and assign specialist roles to individuals – mapmaking, vocabulary, strategy and so on. However, not all of my students became involved in every one of these specific activities in every session and it was clear that at different times some students preferred making maps, or creating strategies, or working directly with words, or with words together with the pictures they had created. It was difficult to discern any fixed pattern in this from casual observation but suddenly these students began exhibiting higher-order thinking skills and using them confidently when previously they had exhibited no potential for such behaviour in my lessons. Above all, what was most noticeable was the degree of involvement, commitment and perseverance displayed by many students and their evident sense of achievement and enjoyment in collaborating, learning and working in highly self-directed ways to achieve objectives they had developed for themselves. What remained unclear to me was the relationship between computer use, content format, individual learning style preferences and successful learning.

I began to wonder if there were ways in which the educationally desirable behaviours of my students might be transferrable to alternative settings - such as my English Literature classes - which were not game or puzzle oriented. Could computer software produce learning benefits from content that engaged the imagination but was more demanding in scope and depth - and was not explicitly a game? My concerns were not about using computers for games or any implied trivialisation of learning in this, for it was clear that my students took *Zork!* very seriously indeed. It was the sustained attention, the seriousness of their application and the associated enjoyment they discovered from intellectual application that I sought to transfer – together with their success in learning. However, one concern was whether the computer would continue to motivate learners once the novelty had worn off. Would it encourage meaningful learning in other contexts and, if so, in what particular ways might it do this? Would different students prefer or need to use such a resource in different ways? Would any learning that took place be manifested in improved examination results or in other affective ways, or would benefits be limited to motivation and enjoyment alone? Would any benefits transpire that could not have been achieved by more traditional approaches? Would using computers produce or encourage any changes in the way I taught and in the ways my students learned? In short, would the use of this technology sufficiently repay the necessary investments of time and resources involved in using it?

Inspired by my early experiences with *Zork!*, I developed my own computer software to help students studying set texts for national English Literature examinations, drawing on my experiences in the classroom with students to refine it and take advantage of the increasingly sophisticated multimedia capabilities of home computers to introduce more ambitious programs which made use of graphics,

animation and sound as these became more widely available over the next twenty years. The initial and subsequent versions of the software proved popular and eventually reached a stage of development where I published titles for eight of the most frequently set literature texts through a company I set up for that purpose. These programs, developed initially as an exploration in curriculum development, are now in use in many schools throughout the UK.

From the beginning the software seemed to be successful from my subjective point of view, but I was concerned to establish whether its apparent effects were real and measurable. Did the use of this multimedia computer software offer pupils valuable learning opportunities that were unavailable in traditional classroom environments and, if so, did these enable a useful variety of approaches to academic work for pupils which improved their learning? From my perspective as a practicing teacher I was not aware of whether there was much systematic research on these matters and I had used no published research or theoretical underpinning in the design of the software, nor had I made any systematic analysis of its effects. This would perhaps seem surprising now, but these were early days in the development of home computers, the use of computers in schools, the design of human-computer interfaces and especially the use of multimedia and because of this the training of teachers and of those in service at this time had not embraced their use.

This was brought home to me most forcefully in some of the training sessions I ran for teachers across the county of Kent at this time. During these sessions we would talk as a group about what use we were making of the school computer and any associated concerns or issues that teachers felt needed addressing. It soon became clear from these conversations that teachers tended to use their school computer mostly as a ‘treat’ for students who had finished their classwork early. The software available for these machines at this time was generally very limited and comprised mostly of drill and practice programs designed, for example, to help students learn basic mathematical skills or simple words in other languages. Teachers tended to let students play with these programs but did not often use them as a resource in their teaching. Usually this was because of the limited number of machines, as even those schools who had more than the original government machine tended at first not to have more than an additional four or five because of their expense. Many teachers were content to leave students playing a computerised game of ‘hangman’. This struck me as a dreadful waste of the equipment and as something that sent all the wrong messages to students: hurry to get your classwork finished and you can play on the computer; computers are only useful for passing the time; teachers do not see much educational advantage in computers; computers are only for ‘clever’ children and so on.

To underscore my concerns I wrote a simple program in BASIC to illustrate one of the key educational and pedagogical opportunities that I thought teachers could take advantage of. The program was a version of the game ‘Guess the animal”. In this game, one player thinks of an animal and the other players try to work out what it is. If they do so they win the game and the player who guessed the animal correctly takes the place of the first player; otherwise the original player gets another turn and thinks of another animal. The other players are allowed to ask only one question at a time of

the first player, in turn, and every question has to be answerable with the single word 'Yes' or 'No' by the first player.

The program that I wrote played the part of the other players and began by asking the pupil using the computer to think of an animal. When they had done so, they were told to press the 'Enter' key. The program always responded when the 'Enter' key was first pressed by asking 'Is it a ferret?'. The pupil would type in either 'Yes' or 'No' to every guess the computer made and then the computer would take its turn in responding with another question. The program was written in such a way that logical steps were followed through a classification structure by eliminating whole groups of animals with each question the computer asked. For example, if in answer to the ferret question the pupil typed 'No' the computer would next ask 'Does it fly?'. Depending on the pupils answer ('Yes' or 'No') to this question the program moved through to flightless animals and then might in the following turn ask if the animal lived in the sea. Similar steps were then followed to narrow down the type of animal to a single group and at that point the program would take an animal name from that group in its limited database and present it to the user in the form of 'Is it a xxxx?' where xxxx was an animal that fitted the classification tree at that point. Quite deliberately only one animal was included for each group in the database so that the computer quickly ran out of choices and ended up saying 'I give up. You win! What was the animal you were thinking of?' Students and teachers found this hugely entertaining. For the purposes of this explanation let us assume that the pupil was thinking of an elephant and the computer's last unsuccessful guess had been 'Is it a cow?'. Having conceded defeat, the computer would then ask the key question that was the whole point of the program. In this case the question would be "Please type in a single question that would allow someone to tell the difference between an elephant and a cow. The question must be one that can be answered by 'Yes' or 'No'". Once the pupil had typed in their question the computer would then ask "Please type in the correct answer to your question – is it 'Yes' or is it 'No'?

The key feature of this program was that the new animal and its question (along with the correct answer) were then added to the program's database in the correct part of the decision tree. If any future pupil reached the same point again the computer would present the key question and in light of the answer would present 'Is it an elephant?' or 'Is it a cow?'. This very simple learning algorithm underscored what I wanted to convey to teachers about the use of computers: that computers could be used to make learning engaging (there is nothing wrong with that); but they could also be used to help students to think; to re-examine what they already know; to classify and structure their knowledge, to learn how to ask the right questions; and to put more intellectual energy into the computer than came out of it. Looked at this way, the computer is indeed a 'learning machine', but not in the way most people thought about this at the time, where the consensus seemed to me to be that the computer was a machine for teaching students.

Admittedly I was a little discouraged when one teacher who had not used the program before became panicky at the machine's first response and shouted to the rest of the group "It knew I was thinking of a ferret! That's really scary - aren't computers fantastic!" It took me quite a while to reassure him that it always started by asking if

the animal was a ferret and that the computer was no more able to read his mind than I was. Whilst they were still in awe of computers, some teachers could see the point I was making but were still at a loss to know how they could build upon this approach to create a very different pedagogy to the drill and practice they often used. Teachers at that time did not commonly have the training, ability or interest to start learning programming so that they could develop learning packages for pupils. Nor did that seem to me to be a sensible way forwards. I have always felt that teachers should concentrate on learning and teaching, not on such things as mastering computer programming – particularly as most software at that time that could be used for this was distinctly user-unfriendly. There was virtually nothing in the way of the high level software-building tools that are available today.

3 Teacher Training and Changing Times

So although in the early 1980s I was amongst the first small group of teachers in the UK to use computers in mainstream schools to enhance learning, my early experience had already made me aware that whilst the technology seemed to have great potential for supporting learning it also was likely to have significant limitations. In contrast, many government initiatives then and now seem to rest upon on an almost blind faith in the presence or use of computers to somehow provide solutions to many intractable, long-standing, social, educational and economic problems. My early experiences of using computers was more nuanced and had already suggested that their benefits were likely to be very dependent upon applying them in specific and particular ways, of which educators in general were only just beginning to become aware.

So the questions that first intrigued me in the 1980s remained unanswered and remained so through the 1990s and still inform much of the discussion in the academic literature I come across today. Why these same questions still remain topical and, more importantly, the answers to them still somewhat unclear after over thirty years of computer use in schools seems puzzling, but why these questions did not receive appropriate attention in the 1980s is easier to understand.

When I was preparing to become a teacher during the early 1970s, teacher training commonly included exposure to the study of the history of education, to educational philosophy and to the writings of those interested in curriculum development. Aspiring teachers at this time were also introduced to the idea that a learner-centred approach to classroom pedagogy was more desirable and effective than one centred on the teacher. As a consequence of this, teacher training in this period commonly included reference to the writings of thinkers such as Dewey and his arguments that students in schools needed to both experience and interact with the educational curriculum and should therefore become collaborators in partnership with teachers in the experience of learning. However, Dewey was also esteemed for his advocacy of the need to maintain a balance between an active child-centred approach to pedagogy that took account of the experiences and interests of the pupil as well as the need to

respect the important role of the teacher in drawing meaningfully upon the pupil's prior learning and in choosing and presenting important curriculum content [16], [17].

These approaches to learning and teaching had been given impetus by publications in the UK such as the Plowden Report [23] that, although focussed largely on the primary sector, was seen to hold important lessons for education more widely, as reflected in its opening comments:

> *At the heart of the educational process lies the child. No advances in policy, no acquisitions of new equipment have their desired effect unless they are in harmony with the nature of the child, unless they are fundamentally acceptable to him. We know a little about what happens to the child who is deprived of the stimuli of pictures, books and spoken words; we know much less about what happens to a child who is exposed to stimuli which are perceptually, intellectually or emotionally inappropriate to his age, his state of development, or the sort of individual he is. We are still far from knowing how best to identify in an individual child the first flicker of a new intellectual or emotional awareness, the first readiness to embrace new sets of concepts or to enter into new relations. [23]*

Trainee teachers were encouraged to apply such ideas as well as those of Dewey and Cole et al. [7], [16], [17], and especially of Piaget [38], [39], whose thinking clearly influenced Plowden. Piaget suggested that through a process of objectification, reflection and abstraction children develop their own schemas (mental frameworks of structured groups of concepts), complex predictive models and their understanding of their physical and social environments and that they do this through exploration and the iterative use of abstract reasoning to deduce 'rules' operating in a particular environment or setting. Teacher training programmes encouraged this approach as an effective way to develop a more child-centred pedagogy and also promoted Vygotsky as an influential related thinker and in particular referred to his work on the role of play in facilitating the development of abstract ideas and meaning; the part these have in developing a child's higher mental functions were much in evidence in professional discourse at the time [7]. Vygotsky also identified the important social role of collaborative learning and related this to his concept of the 'zone of proximal development' in the advancement of individual learning through collaboration. These ideas, together with those of Piaget and Dewey, featured strongly in the newly emerging honours degree programmes of teacher training that I and my contemporaries experienced but were also subject to cautions about the use of ICT from the literature of the time which observed that children in their early school lives commonly learn to accept "delay, denial and interruption of their personal wishes and desires" [27, p.18]. Teachers in classrooms of the time were mainly concerned to "decide on a set of activities" and then "focus their energies on achieving and maintaining student involvement in those activities" [27, p.162]. Writers still felt the need to continue to make a similar point almost forty years later:

> *"New technology's potential to change the culture of the classroom and the relationship between teacher and students is important, since traditional classrooms are not ideal learning environments." [27]*

My own professional training and experiences with ICT, particularly with *Zork!*, had therefore left me sensitive to the possibilities offered by this newly available technology and its potential for promoting collaborative and individual learning, for encouraging pupils to take more control of their learning to collect and synthesise information thoughtfully, for promoting the development of critical thinking and for developing intellectual constructs and theories about scenarios and relationships. As a result of my training and early experience with computers I was persuaded of the superiority and desirability of a more student-centred and experientially-based approach to learning and teaching and excited by the possibility that ICT may be a powerful way to bring these things about. This was not a unique experience, and many of my contemporaries during the 1980s and 1990s who started incorporating ICT into the classroom practice found that its use allowed the historical continuity of teacher-centred pedagogy to be replaced by more student-centred approaches [10].

The supporters of Plowden and the advocates of collaborative and student-centred learning were, however, not without influential and powerful opponents who had been growing in prominence since the 1970s. Some commentators and politicians mounted a concerted drive against such approaches - even though their grounds for doing so often appeared to rest largely on dogma and opinion and tended to ignore evidence contrary to their agenda. They accused child-centred approaches and the dominance of what they dubbed as 'trendy educationalists' of being responsible for what they identified as a decline in educational standards [45]. Piaget's ideas of cognitive development through step-wise stages where learners developed through their own active efforts informed much of the Plowden Report and against this rising criticism the recommendations of both Plowden and therefore of Piaget fell out of favour [21]. The so-called 'Black Papers' of 1969 added fuel to the debate in blaming much of what was seen by their authors as wrong with UK education on the influence of Plowden (for example see [8]). Difficulties surrounding a small number of problematic and idiosyncratic schools, such as at the William Tyndale school in North London in 1974 [20], exacerbated matters and were seized upon by these critics of education and as a result of all this Plowden came to be increasingly marginalised.

The then Prime Minister Jim Callaghan's 'Ruskin Speech' at Ruskin College, Oxford in 1976 also marked a turning point in these debates and the emergence of more overt political control of the curriculum and teacher pedagogy. There was a prevailing view in many teacher training institutions in the late 1970s, including the one I attended, that this firmer tone signalled a clear intention to take action and was probably due to frustration at what some politicians saw as the stubborn reluctance of teachers and schools to listen and change. From 1979 onwards the Conservative government, led by Margaret Thatcher, embarked upon a process of political intervention in education that led to the imposition of a subject based National Curriculum in the 1988 Education Reform Act.

Within the National Curriculum ICT then emerged as an important area that all subject teachers were and still are required to address and the government's Office for Standards in Education (Ofsted) is required to inspect. This area was and continues to

be characterised largely by 'key concepts' such as: individual capability in ICT use; communicating and collaborating; exploring ideas and manipulating information; understanding the impact of ICT; and thinking more critically about using ICT and information in general. The National Curriculum indicates that these key objectives should be achieved through the development of 'essential skills and processes'. Teachers, such as those of English Literature at Key Stage 4 (for children aged between 14 and 16) are for example required to promote the use of ICT for: 'Finding information'; 'Developing ideas'; 'Communicating information'; and 'Evaluating information' [41]. The National Curriculum emphasises the use of ICT for generic instrumental purposes and promotes its utilitarian adoption across the curriculum. In this regard the use of ICT by pupils for finding information, developing ideas, communicating information or evaluating their own work is not unlike (and arguably no better than) the way such objectives might be achieved by a teacher through the use of writing, classroom discussion, promoting the reading of books or by getting their students to use a library. This point seemed to have escaped the attention of government policy.

The introduction of ICT into schools in the 1980s therefore coincided with a more overtly interventionist stance by politicians towards mainstream public education and also with the fall-out from the continuing 'great debate' about the curriculum and the nature, purposes and responsibilities of teachers and schools. However, my own early experience, particularly with *Zork!*, had by this time led me to already conclude that the 'catch all' utilitarian approach for the use of ICT that seemed to run so strongly through government policy and the National Curriculum was unlikely to discover or exploit many important features that may be unique to this technology for enhancing learning and teaching in specific ways and in particular contexts.

4 National Policy and ICT

During the period of my early experiments with *Zork!* and my first attempts to develop my own software to support the teaching of English Literature in the 1980s, the UK government was busily promoting the wider use of computers in schools. At first this was via the Microelectronics in Education Project in 1980 but this was also supplemented by a range of other, often heavily funded, initiatives.

The transformational promise of digital and other technology for education had been an enduring feature of political rhetoric long before the member of parliament Michael Heseltine launched the 'Superhighways' initiative in the UK in 1995. Digital technology has been consistently offered to the public by politicians as an almost magical talisman for producing educational progress and excellence ever since. The sums of money committed though this field of public policy have been substantial, even when only the major events and policy initiatives during the 1980s and 1990s are taken into account (Table 1).

Table 1. Major financial initiatives for schools 1980-2002

Source	Year	£ (million)
The Microelectronics in Education Programme (MEP)	1980-1986	32
The Micros in Schools Schemes *	1981-1884	15.1
The Technical and Vocational Educational Initiative (TVEI)	1983-1987	240
Microelectronics Education Support Unit (from 1988-1998 merged with the National Council for Educational Technology)	1986-1988	13
The Education Support Grant for England **	1987-1993	90
Multi-media computers in primary schools	1992-1995	10
Education Departments' Superhighway Initiative (EDSI)	1996-1998	10
Multimedia laptops for teachers	1996-1998	27
The National Grid for Learning (NGfL)	1998-2002	700+
Training for teachers and librarians (New Opportunity Fund) ***	1999-2002	230
	Total	1,367.1

* Provided by the Department of Trade and Industry (DTI) who continued to add further funding each year throughout the 1980s from surpluses at the end of their financial year.

** Supplemented since 1993 from the Grants for Educational Support and Training (GEST) scheme.

*** £1.125 billion total spend on this programme, making the overall total over £2.5 billion.

Many of the problems that dogged the ambitious policies for ICT launched in the 1980s and thereafter in the UK, especially those resulting from an over-emphasis on hardware at the expense of teacher training, should have been predictable on the basis of research and evaluation that had already been done [24]. During the 1980s the damaging effects of failing to draw upon prior research was exacerbated within the UK Department for Education and Science and the Department for Trade and Industry by a disinclination to commission any evaluation of the then current initiatives [46].

'Technology' policy initiatives at this time (and also, many would say, those launched subsequently) were also characterised by political desires for tangible success in often unrealistically short time-scales. The promotion of a 'bidding-culture' for resources also often tended to encourage inexperienced individuals and organisations to rush into offering things that turned out to be unattainable. For the ten years from 1987, when initiatives faltered or failed, the DES was under such pressure to deliver on promises made to and by government ministers that key personnel were blamed and "less experienced people were brought in because they were prepared to offer more than could actually be achieved" [46, p.23]. The situation improved in the 1990s with the formation of the National Council for Educational Technology (NCET; funded by the DES) that was required to consult the research community. However, there were still some problems and to take one prominent example the major Teaching and Learning Technology Project was in danger of never being evaluated "probably because of a fear that it might indicate a considerable waste of public money" [26, p.24].

The National Grid for Learning (NGfL) was the single largest contributor of resources for technology to education in the UK and was developed to meet two of the three recommendations of the Independent ICT in School Commission's Stevenson Report [26] - the first of which being to improve teacher training and the second being about the provision of up-to-date computers and the formation of a network to allow teachers to exchange professional information. The NGfL was focussed on promoting higher levels of practical competency in teachers' use of digital technology and on the provision of hardware and infrastructure. Notably, therefore, the NGfL was developed without an explicit overriding educational outcome in mind and in common with many of the initiatives before it, without the support of a body of research underpinning the specific outcomes for pedagogy and student learning that could reasonably be anticipated.

Like many of the initiatives from the 1980s, the NGfL seems to have been based on a belief that teachers would welcome such initiatives and changes with open arms, that these would enhance classroom practice immediately and that teachers would therefore be keen to embrace opportunities to gain expertise in the use of new technology:

> *"Teachers rapidly become enthusiastic once they have regular hands-on access to computers" [27, p.7]*

But the Commission also offered two further key observations:

> *"we do not advocate Central Government ordering large amounts of hardware for schools" [27, p.9]*
>
> *ICT "… should be used in the service of the curriculum, and made available to help teachers to manage the learning process, however that is defined by them." [27, p.15]*

The Stevenson Report was not alone in advising caution in the introduction of ICT into schools and emphasised that such change could be perceived by teachers as threatening, especially as it involved the introduction of highly technical and expensive machines which seemed set to alter the nature of teaching. Introducing effective change in education is often about changing beliefs and attitudes more than anything else and neglecting this has thwarted many interventions:

> "… if ever there is an example of the risk of "death by a thousand initiatives" it is teacher training! It is difficult to blame and easy to sympathise with the consistently critical - and exhausted! - feedback we have received about the number of knee jerk changes made to teacher training. *Changes should be made to the training of teachers to encourage the use of ICT only if Government has a genuine and clearly stated belief about the huge importance of ICT.*" [26, p.22 emphasis in original]

However, other commentators noted that the government's communication of its belief in the importance of ICT was a necessary but insufficient precondition for the successful introduction of technology into schools and that earlier lessons should not be forgotten:

> *"Those who introduce change treat teachers in precisely the same way as they criticise teachers for treating students. Curricula are often introduced in a way that ignores what teachers think and why." [19, p.119]*

Such concerns were also echoed in the evaluation of the Teaching and Learning Technology Programme, conducted by Coopers & Lybrand, the Tavistock Institute and the London Institute of Education, who found that:

> *"… existing (ICT) products need to be embedded into teaching and learning structures for students. This requires the addressing of issues such as cultural change within departments, time for academics to work CBL (computer-based learning) into their teaching curricula, staff development and training and even a fundamental change in the role of teachers in some higher education institutions." [7]*

In contrast to Stevenson's view that teachers generally welcome both change and the introduction of ICT [26], other writers argue that teachers are commonly perceived as opposed to change, that many of them see ICT as just another bandwagon or unwelcome experiment and that many of them feel such encroachments on their practice can safely be ignored because they have little impact on reality; in this view teachers are seen as exercising a sort of practical wisdom [14]. Given that in the event the government ordered large amounts of hardware for schools, made little attempt to involve teachers in defining how it should serve the curriculum and appeared to ignore cautions from writers such as Fullan [19], it is easy to see that an unflattering view of teachers may have gained currency in the minds of some policy makers and politicians.

The seeming preoccupation with the provision of hardware and skills training was not unique to the UK. Similar political imperatives and developments occurred elsewhere and had in common with the UK context an injunction that schools should spend more on computers, with the accompanying expectation that this would of course improve students' academic achievements. For example, in 1997 in the United States the President's Committee of Advisors on Science and Technology and Panel on Educational Technology advocated a three-fold increase for public spending on resources and services related to technology, most of which was to be for equipment and technical infrastructure [12].

In 1998 the United States spent $7.2 billion (2.7% of the total spending on education) on computers in schools, mostly on hardware (74%), although many government advisers and several major reports sought a much greater proportion on software. The five-year spend from 1994-1998 was approximately $29 billion (although by 2001 in real terms this was probably no more than $175 per pupil per year) and some observers argued strongly that this was inadequate: "Until spending levels rise substantially, the impact on students is likely to be severely constrained" [1].

Commentators have pointed out that underlying judgements were being made in decisions to spend money on computers as opposed to other resources and have, in contrast to the technology's arguably unproven worth, drawn attention to research concluding that traditional approaches, such as reduced class size and increased teacher training, confer recognised and substantial achievement benefits for pupils.

For example, the total cost of introducing computer aided instruction (CAI) in Israel between 1994-1996 has been equated to one additional teacher per school per year, and similar resource commitments in other countries have occasioned comment that "this significant and ongoing expenditure on education technology does not appear to be justified by pupil performance results to date" and that "on balance, it seems money spent on CAI … would have been better spent on other inputs." [4, p.761].

Despite similar reservations from observers in the UK, in 1999 the New Opportunity Fund (NOF) continued the impetus of the NGfL and, using funding from the National Lottery, began training teachers in the use of information and communication technology. The express aim of the NOF was to ensure that teachers made effective use of technology and the expectation was that this would "make a significant contribution to the raising of standards of pupils' achievements" in ways "that meets their needs and is delivered in a way which fits into the culture and plans of their school" (ibid). Details of how these objectives were to be attained in practice were not provided.

Many political initiatives for greater ICT use in education, whether originating in the UK or elsewhere, seem founded more on aspiration than on research findings when politicians, government organisations and policy makers are presenting them to the public. Early failures to commission evaluation studies of the impact of ICT provision compounded the impression that political action may have been judged more important by policy makers than the cautious and more measured implementation suggested by observers such as Stevenson [26].

The introduction of ICT into UK schools may have been designed to fulfil a number of goals: manufacturers' desire profit from selling equipment to schools, whilst others may be seeking solutions to the problems perceived by them to have historically crippled education. Others may anticipate that ICT will create a revolution in classroom teaching practices; and yet others do not wish to see poor and minority children left behind in technological expertise. Such coalitions seem to be generally driven by a belief that if ICT were introduced into the classroom it would be used and if it were used it would transform education [10]. The main impetus for such development in both the USA and the UK appeared to be the interactions between a changing job market and the anticipated effects of the developing global economy, about which President Bill Clinton observed:

> *"Frankly, all the computers and software and Internet connections in the world won't do much good if young people don't understand that access to the new technology means … access to the new economy" [44]*

In this President Clinton was echoing a similar sentiment from UK Prime Minister Tony Blair:

> *"Children cannot be effective in tomorrow's world if they are trained in yesterday's skills. Nor should teachers be denied the tools that other professionals take for granted." [15]*

However, the economic imperative for adopting new technology in education may rest upon a misreading of its probable role, an incorrect assumption about the need for workers to have ICT skills and a lack of consensus about what those skills might be and about their precise economic or educational utility. The promotion of the

technology has tended to be dominated by deterministic views of education heavily characterised by simplistic 'cause and effect' assumptions about anticipated benefits [11], [46].

Even in very high-technology contexts, many skilled teachers are strongly inclined to use ICT primarily to replicate their existing teacher-centred instructional practice [11]. Dawes' early study of these phenomena classified teachers as either 'potential', 'participant', 'involved', 'adept' or 'integral' users, depending on the degree to which they integrated ICT into their practice [14]. Whilst Dawes presumed the category into which teachers fell was influenced by curriculum specialism (e.g. science teachers may find ICT more intrinsically useful than PE teachers), she also noted that even with the more specialist curriculum used with older children, where more teachers were in the higher categories, few ever reached further than 'involved' practitioner status. Follow-up studies of such work have tended to concur and have further concluded that frequent use of ICT is confined to a small minority of educators, although teachers' access, technical competence and an orientation toward a constructivist pedagogy in which depth of study is emphasised more than breadth can significantly affect whether teachers are likely to use ICT [4]. Teacher attitudes towards ICT as driven by their enthusiasms, values and existing pedagogy would therefore appear to be important for understanding how far and how successfully the technology is likely to be adopted and applied.

5 Attitudes

During the latter half of the twentieth century digital technology was frequently presented as an exciting solution to a range of educational and social concerns and also as a means by which teachers could adopt educational roles very different from their perceived traditional didactic stance as the transmitters of knowledge [33]. Such changes were thought to be desirable in part because they could enable a more student-centred approach to classroom practice which had long been seen by many as more appropriate and effective [6], [16], [17], [38], [39] and also because the ability of ICT to offer easy access to a huge range of contemporary information was seen as presenting an effective challenge to the view of knowledge as something that was static and fixed [33].

A powerful limitation on the use of computers by teachers therefore seemed to me to stem from their beliefs about the nature of student learning and, leading from these, what type of instruction is best for their pupils; beliefs that are influenced by their own theories about learning and the affordances that are offered by ICT applications [4], [42]. For example, as a result of such beliefs, some teachers then and now may feel that the internet is largely irrelevant to what they are concerned with in classrooms and, unsurprisingly therefore, may feel that its use is of little relevance to their academic values or pedagogy. Some teachers in the 1980s also argued that in any case they were too busy with many other initiatives to find time to use ICT, had no real knowledge of how best to use it and were dissuaded from considering doing so by the expense and time for training, the scarcity of ICT resources, a lack of technical support and in some cases also by the unfavourable attitude of their school's senior management [14], [53].

However, the exposure of teachers to technology can – if done carefully – encourage them to critically examine their educational philosophy and established classroom practice and can facilitate a change to even very strongly held attitudes about pedagogy, as I found during my own experiences with *Zork!* and when demonstrating its possibilities to other teachers [34].

Even today it seems clear that teachers' subscriptions to a particular pedagogy may be a necessary but insufficient condition for changing traditional teaching practices and others have observed that changes to assessment systems and a lot more professional development will also be needed [32]. In addition to this, the issue of technology adoption and its relationship to the learning outcomes desired by assessment that was highlighted by Parr and Fung when reviewing research in this area has provided conflicting guidance [37].

6 Effectiveness, Learning Outcomes and Attainment

Evidence for the effectiveness of the classroom use of ICT, in terms of impact on academic performance, has been mixed over the last 30 years. Different studies have found moderate effectiveness, minimum effectiveness and no effectiveness. Some reports and studies have focussed on the broader impact and effectiveness of ICT, others on game-based learning but relatively few on multimedia. Some observers of the field have argued that effectiveness statements are often of little use in any case because too often they are unaccompanied by details of student ages, the software used, the outcomes sought and information about how the studies were done [28]. Additionally, according to many writers, most policymakers, practitioners and parents do not appear to have examined research and seem to have taken for granted that computers are effective and have then acted to put them into schools.

From the first appearance of computers in schools, three things have made it difficult to evaluate their contribution: this lack of clarity in the research about what ICT 'effectiveness' means and how it should be measured; a lack of research that has compared computer use with other educational options not involving computers; and different assumptions that have been made in the research about the role of the teacher in technology-rich classrooms. These things have made it hard to compare different research, synthesise the results or reach conclusions, but attempts to do so, such as the 1998 study by Kikpatrick & Cuban [28] found that by the late 1990s, *single studies* made up a high percentage of the investigations. These single studies of achievement gains or improvements in student attitude reported positive, negative and mixed outcomes from ICT use in roughly equal measure. Kirkpatrick and Cuban did identify several studies that focussed on distance learning or on applications for disabled or at-risk students, all of which reported positive outcomes, but they noted that few of these studies were rigorous and ten of them that examined the use of ICT in core curriculum areas ranged from being wildly enthusiastic to cautiously pessimistic; beyond this they were unclear in their conclusions.

Following an extensive survey of the literature from this period [37] it was clear that computer assisted learning had until then been shown to be no more effective

than other approaches and may in fact have been less effective than other kinds of intervention. Much that had been written about computers in education had not really been research or scholarship but comment, reporting of informal observation, opinion, or intuitive speculation. The varied and changing nature of computer assisted learning did make rigorous studies in this area difficult but the main problem for researchers was being able to deal successfully with the complex influences and interactions that arose when ICT is introduced into any learning environment.

Claims for a bivariate relationship between computer interest or availability and achievement are not uncommon in the literature although many studies tend to report only positive associations between use and benefit. Such evidence about the relationship between computer availability and the educational achievement of students is drawn upon by many commentators, not least in the political arena. However this can be highly misleading, because computer availability, for example in the home, is also correlated strongly with other characteristics of family background which, when adequately controlled for, reverses many other findings and produces a statistically significant negative correlation [18]. Some quantitative empirical studies, similar to the international 'league tables' for countries published these days, use data from the Programme for International Student Assessment (PISA) and multivariate regression within which are applied extensive controls for student, family and school background effects and a careful analysis of these shows that it is *how* and *what* computers are used for that makes an educational difference.

For example, students may use computers at home for many things (email, games, web access) but these may often distract them from learning and bivariate results for the availability of computers in schools and pupil achievement are severely biased [18], because higher levels of computer availability in schools are strongly associated with higher levels of other educational resources. The correlation between student performance and computer availability at school is "small and statistically indistinguishable from zero" when other school characteristics are controlled for [18, p.360]. As in the home environment, the amount of computer use in school does not directly correlate with achievement and there may be an optimal amount of computer and internet use significantly above zero but below the level of several times per week:

> *"Having a computer at home and using it at school will almost certainly raise some computer skills ... (but) this may come at the expense of other skills ... (which) are the ones that yield significant labour-market returns, not the computer skills" [18, p.375].*

Many of the conclusions from studies in this area have to be interpreted cautiously because they are not based on randomised controlled experimental evidence but on multivariate, descriptive and conditional correlations and may not necessarily "allow for causal inferences because they may also reflect effects of other, unobservable characteristics" [18, p.361]. Their results are, however, a substantial improvement upon the simplistic bivariate correlations found in many other studies which cannot or do not attempt to disentangle them from other factors [30].

In contrast to the emphasis found in the early policy rhetoric, there has grown more appreciation of the importance of pedagogy over and above the presence of the

technology alone in achieving educational benefit from computers in classrooms. In that sense there is growing understanding that the most important questions about educational technology have never been about the technology at all but about how it is used. There appears to be a growing recognition in published research, if not yet in political policy, that the most effective educational outcomes from computer use are likely to be about identifying its unique affordances for learning and teaching, over, above and/or different from those that already exist in established (non-technology) classroom practice.

Writers have tended increasingly to echo earlier hopes that this growing appreciation will produce more one-to-one interaction (child to screen and child to teacher) that is regarded as freer and less intense, where the teacher can become more of a facilitator and co-researcher of learning and where children take more responsibility for their own learning or, as Jackson put it, can become "self-confident, independent thinkers, whether team players or entrepreneurs, capable of acquiring a range of different skills and adapting to several jobs over a life time" [27].

Although some writers conclude that there is now widespread recognition that the educative skills of teachers and not just their technical competences with technology are the determining factor in using ICT to bring about educational improvement [1], it seems clear that some teachers use ICT as part of highly traditional approaches to learning, whilst others are more adventurous and that either can be equally effective in terms of student achievement [9]. There is, however, strengthening evidence that "new technology's potential to change the culture of the classroom and the relationship between students and teacher is important, since traditional classrooms are not ideal learning environments" [49, p.98]. Despite such evidence there are important caveats, as the earlier evaluation of the Teaching and Learning Technology Programme (TLTP) conducted by Coopers & Lybrand, the Tavistock Institute and the London Institute of Education noted:

> *"...existing products need to be embedded into teaching and learning structures for students. This requires the addressing of issues such as cultural change within departments, time for academics to work CBL (computer-based learning) into their teaching curricula, staff development and training and even a fundamental change in the role of teachers in some higher education institutions." [7]*

A recurrent supposition in much of the writing about the promise of digital technology is that we are now seeing a generation of 'digitally literate' students entering education and that this has profound and inescapable implications for schools, colleges and universities. Variously labelled the 'Net generation' [52], 'Millennials' [24], [25], 'Generation Y', the 'Youtube' or 'Facebook' generation [47], the 'Backpack generation' [13], 'Digital natives' [40] or similar, these young people are presumed to represent a challenge to traditional forms of educational pedagogy and content that differentiates them markedly from earlier generations because of their sophisticated technical skills and learning preferences. Writers espousing these views presume that traditional forms of teaching and learning are therefore no longer appropriate and call for significant changes to the philosophy found within classrooms, although examination of these assumptions and assertions has led some to conclude that much of this debate lacks theoretical or empirical support [5].

One of the advantages commonly claimed for software and systems designed for these 'digital natives' is that they are learner-centred, that they apply approaches where pupils can set their own pace and control their own learning using the 'learner-as-explorer' or student as 'discoverer' model [44]. Such pedagogical approaches are concerned with learner activity and owe much to the theoretical perspectives of phenomenography and constructivism. Phenomenography [35] is derived from studies of student learning and uses the complementary concepts of 'deep' and 'surface' approaches to learning to discuss how the former involves deep immersion in a task and a focus on gaining insight into structure and intrinsic meaning whilst the latter uses rapid skimming, scanning and browsing to develop subject overview and broad meaning. Both approaches are thought to contribute essential strategies to effective learning. The origins of Constructivism have been traced back to Plato and Socrates [22] and both perspectives share the conviction that meaning is created by the learner's activities rather than being imposed or transmitted. Learning is therefore characterised as a way of interacting with and critically evaluating the world, to which the learner brings their individual intentions and motives, their existing knowledge and their established perceptions. The acquisition of information is therefore a necessary, but by itself insufficient, condition for bringing about learning, which requires the further stage of bringing about changes to the individual's established cognition. So as a result of learning an individual's conceptions and perceptions of the world become changed.

These issues, publications and theoretical models we have looked at have informed the emergence and growth of arguably the two most significant debates about how best we might understand and exploit the relationship between pedagogy, instructional design, subject content and individual learning and are especially relevant for the application of multimedia ICT in learning. These two debates are located within Learning Styles [29] and Cognitive Load Theory [51], with the latter representing the more rigorous and likely best approach.

Hopefully our current endeavours will help to focus attention on what is important about the relationship between computers and education – and what is not. The critical element will always remain the relationship between the teacher and the student, however that is mediated by communication technologies. One thing seems clear: pursuing political or educational dogma at the expense of what research evidence shows us is misguided and can often lead to the squandering of valuable resources. Worse, it can lead to us failing our children. This is a failure to capitalise on what is arguably the most powerful instrument for changing the relationship between teacher and learner that we have. Most of all we do not want the earlier mistakes to be repeated and we owe it to generations to come to ensure that when listing the evidenced and demonstrable benefits to learning, the history of the first fifty years of the use of computers does not end with an echo from the Dungeon Master in *Zork!*:

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The engravings translate to 'This space
intentionally left blank'
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