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Teaching and learning IT in English state secondary schools: towards a new pedagogy?

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Abstract - Teaching and learning IT in English state secondary schools: towards a new pedagogy?

New Technologies, particularly Information and Communications Technologies (ICTs), have caused profound changes throughout society. A generation of children is emerging that are familiar with multidimensional, interactive media sources that provide immediate juxtaposition and association of diverse images, often originating in widely disparate cultures. They are already immersed in a multimedia 'data storm' (Moshell, 1995). Their understandings and expectations of the world are mediated through their experiences of multimedia and ICTs, and these differ widely from those of preceding generations nourished on linear technologies that separate images and concepts more widely over time, distance and culture. Educating these children using models of teaching and learning that are grounded in concepts of knowing and understanding that are linear and finite will not help them succeed in a technological, global future where multidisciplinary, holistic approaches predominate.

The conflict between the traditional and the new in English state secondary schools is particularly intense in the teaching and learning of Information Technology (IT). Whilst HMI and OFSTED recommend the teacher centred, whole class, didactic teaching strategies that dominate traditional schooling in subjects such as Mathematics, teachers of IT can find these recommendations difficult to put into practice. Teaching and learning IT are inherently constructivist activities, and IT teachers who attempt to implement learning programmes designed from predominantly behaviourist perspectives quickly find that these are less effective. A new pedagogy is needed that is theoretically sound; and that guides teachers in using constructivist approaches within an education system grounded in an inimical behaviourist paradigm.

This paper takes tentative steps towards an understanding of some of the problems and a resolution of some of the issues. For the present, IT teachers may be well advised to take pragmatic, minimalist approaches in developing constructivist strategies to teaching and learning IT. A synthesis of current understandings is attempted as this may be helpful in the short term.

Teaching and learning IT in English state secondary schools: towards a new pedagogy?

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Teaching and learning IT in English state secondary schools: towards a new pedagogy?

Introduction

Although the schools are embedded in our culture and reflect its values, the technological changes that have swept through society at large have left the educational system largely unchanged. In the course of 20 years, a dramatic rift has opened between the process of teaching and learning in the schools and ways of obtaining knowledge in society at large, a rift made obvious by the fact that the process of teaching has not changed substantially, even in the past 100 years.

(Strommen & Lincoln, 1992)

New Technologies, particularly Information and Communications Technologies (ICTs), have caused profound changes throughout society. A generation of children is emerging that are familiar with multidimensional, interactive media sources that provide immediate juxtaposition and association of diverse images, often originating in widely disparate cultures. They are already immersed in a multimedia 'data storm' (Moshell, 1995). Their understandings and expectations of the world are mediated through their experiences of multimedia and ICTs, and these differ widely from those of preceding generations nourished on linear technologies that separate images and concepts more widely over time, distance and culture. Educating these children using models of teaching and learning that are grounded in concepts of knowing and understanding that are linear and finite will not help them succeed in a technological, global future where multidisciplinary, holistic approaches predominate.

The conflict between the traditional and the new in English state secondary schools is particularly intense in the teaching and learning of Information Technology (IT). Whilst HMI and OFSTED recommend the teacher centred, whole class, didactic teaching strategies that dominate traditional schooling in subjects such as Mathematics, teachers of IT can find these recommendations difficult to put into practice. Teaching and learning IT are inherently constructivist activities, and IT teachers who attempt to implement learning programmes designed from predominantly behaviourist perspectives quickly find that these are less effective. A new pedagogy is needed that is theoretically sound; and that guides teachers in using constructivist approaches within an education system grounded in an inimical behaviourist paradigm. Some tentative steps are taken towards this.

Why is teaching and learning IT problematic?

IT has been gradually introduced into the curriculum of English state secondary schools during the past twenty years. In the 1995 revision of the English National Curriculum (NC), IT was identified as a discrete, mandatory subject, although prior to

this it was taught as a part of the NC subject of Technology. The predecessors of IT, that is Information Systems and Computer Studies, were available to a few pupils in some English state secondary schools from the early 1980's. IT is a relatively new subject and its introduction, though gradual, has been particularly problematic because:

- the study of IT requires access to more expensive hardware, software and communication technologies more frequently than other NC subjects. For example, in Mathematics, the introduction of graphic calculators is much less expensive per pupil than even the cheapest computer, and access to them is required less often.
- the technology that underpins the study of IT changes rapidly and often unpredictably, with the result that schools must re-equip themselves much more frequently than in other subjects. For example, in Mathematics, the texts used do not change significantly year on year whereas IT hardware and software are considered obsolete after three to five years.
- there is insufficient hardware in many schools for pupils to have access whenever they need it, and pupils may have to share computers even in IT subject studies (Goldstein, 1997).
- many teachers of IT lack qualifications in IT or computing, particularly at degree level or above, and very few have been specifically trained to teach IT, as the TTA only approved PGCE and BEd courses in the subject of IT for the first time beginning in September 1996 (Crawford, 1997a; Sellinger, 1997a; QCA, 1997, p8). In contrast, the training of teachers of all other subjects of the NC is relatively well established.
- teachers of IT must regularly learn new concepts, and re-learn old skills in new contexts, as the tasks that can be accomplished using IT are extended. For example, the recent availability of Internet access to schools has required IT teachers to learn about e-mail and Web browsers; and to re-focus their programming skills so that they can build Web sites using HTML; and to be aware of new Web related features in familiar software, such as wordprocessors.
- teachers of IT have greater difficulty controlling the focus of pupils' work in the classroom because, for example, pupils may have full access to all the features of the software they are using, and to all other installed software. In other NC subjects, teachers have much greater control over the texts, worksheets and other learning resources available to pupils.
- pupils may have more extensive IT skills than their teachers as they often have access to more modern computer equipment at home and teachers generally rely on older equipment at school (Cuthell et al, 1997).
- there is confusion over curriculum content. The current English NC orders for IT are relatively vague compared with those for other subjects. For example, observe the contrasting specificity between these statements taken from the key stage 3 programmes of study for IT and those for Mathematics.
IT: 'Pupils should be taught to use a range of IT equipment and software...' (DfE, 1995a, p4)
Mathematics: 'Pupils should be taught to understand and use Pythagoras' theorem..' (DfE, 1995b, p16).
- pupils' levels of attainment in IT are generally lower than in other subjects (Goldstein, 1997; OFSTED, 1995)
- IT has a more extensive role throughout the school than most other subjects. IT is a cross curricular skill, and there is a requirement in the statutory orders for most other NC subjects that IT must be used to support teaching and learning. In

addition, IT is used extensively for school management and administration (Crawford, 1997b).

Some of the above difficulties are exacerbated by schools' lack of staff with expertise in teaching and managing IT in secondary schools, and more effective training, planning and resource management would be likely to lead to improvements (Crawford, 1997b). In addition, some are aggravated by fundamental differences between the traditional approach to schooling and those inherent in teaching and learning IT. I argue below that whereas the traditional approach to schooling is best described from behaviourist/objectivist perspectives, the teaching and learning of IT is inherently constructivist, and that this is in itself a source of friction.

Inimical paradigms? - behaviourist and constructivist perspectives of teaching and learning

On an epistemological continuum, objectivism¹ and constructivism would represent opposite extremes. (Gergen, 1997)

Behaviourist descriptions of the learning process consider only those outcomes which are overt, observable or otherwise measurable, disregarding descriptions of the development of individuals' cognitive and metacognitive strategies and other internal processes as unreliable (Black, 1995; Burns, 1980, p4; Gergen, 1997; Skinner, 1953). Learning is considered to have taken place only if there is an observable change in behaviour; learners are encouraged by rewards and inhibited by punishments.

Skinner (1953) and Crowder (1955, in Child, 1973, p114) developed programmed learning teaching systems based on behaviourist principles. Typically, these were hierarchically structured with tightly specified behavioural objectives; and incorporated provision for incremental learning gains; immediate feedback and regular reinforcement. The design of such learning programmes is highly teacher or designer centred; possible learning outcomes are restricted and learners are given little if any opportunity to develop perspectives or undertake tasks not built into the programme; and the characteristics of individual learners or the context in which learning will take place are often ignored (Brown, 1995; Moshell, 1997; Wilson, 1997).

As a result of the ascendancy of the behaviourist designer centred view of teaching and learning, school teachers are traditionally regarded by their pupils as 'gods of knowledge' (Phillips, 1997) who have total mastery of the subject content they teach, and design and control all the learning that takes place within their classrooms. 'The dominant educational paradigm is didactic instruction where learning is viewed as an information transmission process' (Soloway, 1997), and teaching consists of the transfer of knowledge from teacher to pupil. Teachers develop linear sequences of tightly structured, highly focused learning materials, and assess pupils' learning in relation to the specific learning outcomes built into them (Fosnot, 1996, p9). From a

¹ Objectivism and behaviourism are similar and supporting paradigms and these terms are generally used interchangeably. In essence, objectivism is a psychoanalytic theory of mind, and behaviourism is its equivalent in psychological learning theory.

behaviourist perspective, the outcomes tested during the assessment process should be only those built into the learning programme by the teacher, and no distinction should be made between identical outcomes whether these are produced by rote learning or as a result of deeper understanding (Julyan et al, 1996, p55).

This model of teaching and learning reflects objectivist assumptions that the world is external, unchanging and structured (Heylighen, 1997; Jonassen, 1997; von Glaserfeld, 1996); and that there is one world with ultimately one valid explanation of it. Consequently, learning is considered to be being told what is known about the objects in this external world and the relationships between them, and teaching is the transmission of this knowledge to passive learners (Fosnot, 1996, p205).

In contrast, constructivists believe that knowledge 'does not exist outside a person's mind' (von Glaserfeld, 1996) and believe that learning is the organisation of the individual's internal cognitions and experiences not the discovery of an external, objective reality. Learners create their own knowledge and understanding through active engagement with realistic tasks in authentic contexts using actual tools, and as there are many learners, there will be a multiplicity of understandings, though these will be moderated through social discourse. Learning is seen as the process of 'assimilation, augmentation and self reorganisation of incomplete mental structures' (Soloway, 1997), and is considered to be most effective where learners are pro-active in and control the construction of their own explanations (Davidson, 1995; Gergen, 1997; Strommen & Lincoln, 1992, p2).

From the constructivist perspective, the role of the teacher and the purpose of learning materials is to facilitate active learning, during which learners construct their own holistic understandings, rather than design tightly specified, linear teaching programmes that impose given knowledge structures on the learner (Strommen & Lincoln, 1992). Teachers cannot transfer meanings or concepts direct to passive learners but can only orientate their conceptual construction process (von Glaserfeld, 1996, p7). Learners are expected to have ownership of the learning process, experience with construction of their own knowledge, and self-awareness of the knowledge construction process (Boyle, 1997, p76; Wilson, 1997). There is an emphasis on process rather than specific outcomes and, as a result, learning outcomes will be less predictable and may vary from learner to learner.

Individual constructivists also build their own understanding of constructivism itself, so that there may be as many varieties of constructivism as there are constructivists (Ernest, 1995 quoted in Gergen, 1997). Gergen distinguishes between several types of constructivism, identifying radical and social constructivism as significantly different strands. Radical constructivists give less credence to shared understandings in assessing the validity of knowledge than social constructivists who see consensus between different subjects as the 'ultimate criterion to judge knowledge' (Heylighen, 1993). The development of shared cultural knowledge constructed through collaborative social discourse is an essential part of social constructivism and is valued by radical constructivists as a means of testing the products of individual cognition. Consequently, some form of collaborative learning can also be expected to be a part of the constructivist experience of teaching and learning.

To summarise, behaviourists/objectivists believe that the world is 'out there'; that there is only one 'true' world; that teaching is telling learners about this external world; and that learning occurs only when some observable behavioural change is demonstrated. In contrast, constructivists believe that knowledge is 'inside'; that there are multiple individual representations of the world which are moderated through collaborative, social discourse; that teaching is providing realistic tasks, actual tools and authentic contexts to facilitate each individual's process of conceptual construction; and that real learning is always at a deeper conceptual level than mere behaviour. Evidently, behaviourism/objectivism and constructivism are indeed inimical paradigms, and are at least in contention as alternative and opposite understandings.

To what extent has behaviourism influenced English state secondary schools?

The influence of behaviourism in English state secondary schools is extensive, and has affected the curriculum, teaching methods and assessment; and the evaluation of performance is entirely driven by behaviourist understandings of what constitute reliable indicators of a successful education.

What teachers teach is prescribed in considerable detail through the statutory NC handed down by central government. For classroom teachers this is equivalent to knowledge of the objectivists' unchanging, external world. All state schools have the same or very similar curricula, reducing the flexibility of individual schools to respond to new opportunities and challenges. This conformity is mandatory and is ensured by 'unrelenting pressure from the centre' (Skidelsky, 1997), and reinforced by the new School Standards and Framework Bill which gives 'unprecedented powers to the secretary of state to intervene across the board in the British school system' (Dorrell, S. quoted in Ward, 1997). There is increasing conformity and central control (Mortimore et al, 1997) and non-conformist schools, such as Summerhill, that challenge the mandatory impositions of the state are threatened with closure by OFSTED (Clutterbuck, 1997). It is possible that IT would not now be a part of the school curriculum had a prescriptive, monolithic NC prevented its experimental introduction in some schools during the early 1980's.

OFSTED, HMI and government encourage teachers to adopt didactic, whole class teaching methods focused on the achievement by pupils of tightly specified learning objectives assessed through immediately observable outcomes. This includes teacher-directed exposition, consolidation and review; and provision for sequential, incremental progress; positive feedback; repetition and practice; and formative assessment and remedial exercises (Cockroft, 1982). This approach is very similar to that used in the construction of programmed learning teaching systems based on behaviourist principles.

The success of the transfer of knowledge from teacher to pupils is usually judged by the extent to which pupils can recall this in tests and examinations as 'politicians insist on ... methods which encourage students to regurgitate their received knowledge' (Martin, 1997). These rarely explore pupils' cognition, tending to reward evidence of 'correct' answers whether or not these are memorised or arise from deeper

understandings, and as a result, the separation of content from context is prevalent (Brown, 1997). Teachers are driven by ‘targets, benchmarks, inspections and action plans’ (Wilce, 1998), including pupil learning targets, school performance tables and other quantitative indicators that are used to measure the success or failure of schools, and this is rewarded or punished by public exposure and threats of ‘special measures’. There are clear parallels here with the emphasis in the behaviourist model of learning on observable outcomes, encouraged by rewards and inhibited by punishments.

Is teaching and learning IT inherently constructivist?

There are general characteristics of IT that facilitate a constructivist approach (Inge, 1996) and features of teaching and learning IT in English state secondary schools that make a constructivist approach the only workable methodology. These are reviewed below.

Because of the rapid and often unpredictable development of IT hardware and software, IT teachers must constantly relearn their subject skills and knowledge, and consequently have great difficulty in maintaining a thorough and comprehensive understanding of the content domain. Moreover, the multiplicity of real exemplars of particular types of software, for example, the plethora of different wordprocessors, means that knowledge of particular operational skills is often less useful to IT teachers than an understanding of the potential functionality of different types of software. In addition, pupils may have access to and better knowledge of more modern IT resources. Consequently, IT teachers cannot be ‘gods of knowledge’, and will not have the oversight and understanding in depth and detail needed to design and construct behaviourist programmed learning materials or similar resources for the classroom except where the focus of these is very narrow.

In general, IT teachers have more difficulty maintaining the focus of pupils’ work, and those who adopt didactic, whole class, teacher centred approaches to teaching IT often struggle to retain pupils’ attention. Even though pupils may be highly motivated, they can be disinclined to sit and listen to the teacher or to wait for other pupils to complete their work as the teacher takes the whole class step-by-step through precise operational procedures. In addition, IT teachers are less able to restrict pupils’ access to only those learning resources and activities that are particularly relevant to the set task as pupils using IT resources usually have access to the full range of software available and the wide range of features within each piece of software that are provided to meet the diverse needs of many different professional users. As a result, pupils may inadvertently or otherwise use different pieces of software or features of the software that are not relevant to their work, and become distracted or irretrievably stuck. Similarly, where learning materials based on traditional systematic instructional design are used, learners tend to deviate from the given sequence or abandon it entirely, preferring to try and make sense of the situation rather than following a series of rigid steps (Boyle, 1997, p13).

Learners apparently prefer to attempt to construct their own understandings and seem to want ‘meaningful interaction with real tasks rather than formal drill and instruction’ (Boyle, 1997, p13). This is possible because the software tools used by learners are

frequently similar and often identical to those actually used in commerce and industry, for example, in English state secondary schools pupils often have access to Microsoft Windows and the Microsoft Office suite comprising of Word, Excel, Access, etc. This meets the constructivist requirement that actual tools should be used by learners.

Because IT teachers cannot be ‘gods of knowledge’ and must anticipate that pupils’ attention and focus will wander then they must be prepared to encounter in the classroom areas of their subject content domain that they do not know or fully understand (McKenzie, 1997). Consequently, they must expect to learn at the same time as pupils and to take the lead in learning with them. If pupils follow routes that teachers have not anticipated, teachers will at times accompany them, that is, teachers and pupils will learn together. Furthermore, as there is often insufficient hardware for each pupil to have the sole use of a computer (Goldstein, 1997), pupils are likely to work in small groups of two or three. In such circumstance, pupils will almost always help each other and check learning outcomes with each other, and if these are different some exploratory discussion is inevitable. Pupils are likely to investigate and develop not only their own ideas but the ideas of other group members (Phillips, 1997). Evidently, learning IT is almost always likely to involve an element of collaborative learning, and at a minimum this will be teachers learning with pupils.

To summarise, the only workable method of teaching and learning IT in English state secondary schools is constructivist because teachers cannot be ‘gods of knowledge’ as the content domain and the technology change too rapidly, and pupils may have better knowledge of these than teachers. This obstructs detailed, systematic instructional design and teacher centred, didactic control of the learning process. In addition, pupils apparently reject such approaches in favour of active engagement with real tasks, and are able to do so as the actual tools used in authentic contexts are available for their use in the classroom. In addition, there is always an element of collaborative learning.

The challenges: towards a new pedagogy?

What is the impact of using constructivist approaches to teaching and learning in the classroom on an education system which is built on behaviourist principles? It has been suggested that behaviourism/objectivism and constructivism are inimical paradigms, and that the English state school system is heavily influenced by behaviourist understandings, whereas there are general characteristics of IT and aspects of teaching and learning IT that are inherently constructivist. As a result, some dislocation should be expected, and there may be friction.

Characteristics of this dislocation and the resulting friction are:

- teachers expect the IT NC to tell them what to teach but it is vague;
- IT teachers are unlikely to be ‘gods of knowledge’;
- IT teachers are likely to find traditional didactic teaching strategies much less effective;
- traditional relationships between pupils and teachers are undermined by the shift from the perception of teachers as ‘gods of knowledge’ to directors of or leaders in the pursuit of knowledge;
- pupils questioning of received knowledge is likely to further undermine the traditional authoritarian role of the teacher;

- active styles of learning in IT can conflict with passive styles of learning prevalent in other school subjects;
- the separation of content and context prevalent in many other subjects is much less acceptable in IT as it more obviously leads to a sterile learning experience (Wilson, 1997);
- inflexible curricula cannot easily accommodate new and rapidly changing technologies;
- didactic teaching and individual assessment rarely accommodate collaborative learning;
- the autonomy of individual teachers is reduced because team teaching is more common as IT teachers work with teachers of other subjects.

The challenge is to resolve the disharmony between the dominant behaviourist approach to education within the English state secondary school system, and constructivist approaches to teaching and learning IT. Is this possible? It has been argued that theoretically there is fundamental, unavoidable conflict between these two paradigms, however, IT is taught in schools so teachers must find pragmatic ways of resolving of this conflict. Unfortunately, this area is not well understood or researched and there are no guaranteed, off-the-shelf solutions available. There is a 'systemic lack of awareness of the appropriate uses of technology' and this is a major impediment to defining new pedagogical practices (Strommen & Lincoln, 1992).

Obvious maladaptive responses to new technologies are to oppose them; to ignore or avoid them; or to think up ways of using them that require little or no adjustment to current practice. The first has a history reaching back to the Luddites and no doubt beyond. The second is observable from time-to-time, for example, the author has known computers that have been delivered to secondary schools remain unpacked and unused for a year or more because the teachers who were to use them did not welcome them. Such anecdotal tales are not unusual. Monaghan (1997) believes that the purpose of recent revisions to the English A-level Mathematics syllabuses is to ensure that the use of graphic calculators is avoided. The third response is apparent where there is a lack of integration of IT when it is used to support the teaching and learning of other subjects, and this too is not an uncommon practice. A common example is the use of a wordprocessor to produce a neat printout of work that has been handwritten previously rather than using it as a tool to assemble and mould text. Such responses at best 'relegate technology to a secondary, supplemental role that fails to capitalise on its most potent strengths' (Strommen & Lincoln, 1992) and are illustrative of the use of new technology as a crutch rather than a tool (Philips, 1997).

Sellinger (1997) in an article entitled 'Defining a pedagogy for IT', asks 'What does it mean to teach IT?'. In answer, Sellinger suggests ways to encourage pupils to develop their cognitive and metacognitive strategies which include:

- 'It is OK to make mistakes
- Collaborative learning is positively encouraged
- Peer support is as valuable and as legitimate (if not more so) that teacher support
- Students are empowered through taking control of the technology
- The locus of control moves away from the teacher'

These recommendations seem reasonable on-the-whole and are recognisably constructivist. However, statements about the comparative value of peer support and teacher support are unsound unless based on unequivocal research evidence. Social

constructivists might well consider peer support to be as valuable as teacher support though those who agree with Vygotsky that scaffolding can extend concept development might disagree. Sellinger recognises that strategies for developing pupils' cognitive and metacognitive strategies 'need to be formalised and are not currently situated within the IT community of practice', however, there is no attempt to develop these in ways grounded in learning theory and research, although this is perhaps an unreasonable expectation in a short, brainstorming article. More seriously, there is no recognition of the need to describe practical means of restraining intrusions from the prevailing behaviourist system of schooling. For example, it is unlikely that it would be acceptable within the current system of schooling for the locus of control to move away from the teacher if what is meant is control of pupils' behaviour in the classroom; it may be more acceptable for strict control of the learning process and its outcomes to move away from the teacher.

One promising approach to developing constructivist strategies within a behaviourist system is that of minimalism. Observation of people learning IT skills, using materials incorporating the principles of traditional systematic instructional design, indicated that these materials were not effective as users abandoned them and instead tried to make sense of what they were learning through task engagement. As a result, Carroll (in Boyle, 1997, p102) developed the minimalist approach to the construction of learning materials which seeks to minimise the impact of 'intrusive instructional materials' and support the natural strategies of learners. Minimalist principles were derived for the design of learning materials, and these are (from Boyle, 1997, pp13-14 & p103):

- the learning environment should be user centred;
- get learners started on real tasks as quickly as possible;
- provide support for exploration, reasoning and improvisation;
- mistakes are an essential part of the learning process ;
- error recognition and recovery should be strongly supported;
- intrusive instructional material should be reduced to a minimum;
- learning materials should be structured and modular;
- users should not be constrained to a pre-defined learning sequence;
- users should be free to access those learning materials they require and ignore those they do not.

These principles are apparently constructivist but recognise the need for development within the skeletal framework of systematic instructional design. It is the learner's preferences that drive selection and structuring, and the rigidity and intrusiveness of the traditional approach is minimised. In this case, the domain considered was mainly text based learning material for IT skills and this is not the entire classroom or school context, even so, this notion of accommodating constructivist approaches within minimised behaviourist structures may well be helpful.

It may be that IT teachers would be well advised to take a pragmatic, minimalist approach and develop constructivist approaches to teaching and learning only within their own classrooms. The utility of this approach is evident if it is considered what a national system of schooling would look like if the constructivist paradigm prevailed throughout. It is possible that it would look quite different, for example, it is unlikely that the subdivision of the curriculum into subjects and the associated organisation of schools into subject departments would remain intact as this does not fit with the conception of holistic knowledge construction driven by learner enquiry which is

unlikely to recognise subject boundaries. To some extent this breaking down of subject boundaries has been recognised by attempts to teach IT entirely across the curriculum and not as a subject in its own right. In addition, age related cognitive maturation might be considered inappropriate and the progression of cohorts of pupils through schools in year groups abandoned. However, whilst a school such as Summerhill may well be effective in 'redefining notions of what constitutes education and learning' in these ways (Clutterbuck, 1997), it is a small school and it is not clear whether a national system of schooling could function effectively without more hierarchical, systematic organisation into subject and year groupings. Perhaps it could, but there are no reliable precedents. Indeed, it is not clear that a theoretically pure constructivist approach to education would necessarily incorporate schools or any other type of educational institute offering formal courses as these move the focus of control away from the individual learner.

It is arguable that constructivist cognitive activity is an unavoidable precursor to deeper understanding and is inherent in all concept development. This suggests that constructivist approaches should be effective in all teaching and learning, and some work has been done in developing these within teachers' classrooms in Mathematics, Science, Computing, Language, and the Arts (Fosnot, 1997; Philips, 1997; Soloway, 1997), but this is often carried out by educationalists who are evangelists for a 'paradigm shift in education' in favour of constructivism (Fosnot, p216). However, it has been argued here that whether or not constructivism offers better descriptions of the process of teaching and learning in general than behaviourism/objectivism, the only workable way of teaching IT is constructivist, and within the English state secondary school system probably minimalist.

Some suggestions for teachers who wish to adopt constructivist strategies are (synthesised from Brooks, J. G. and Brooks, M. G., 1993; Brown, 1997; Boyle, 1997; McKenzie, 1997; Murphy, 1997; Phillips, 1997; Sellinger, 1997; Strommen & Lincoln, 1992; Wilson, 1997):

- encourage and expect pupils to take responsibility for their own learning;
- nurture pupils' curiosity and interest;
- set realistic tasks in authentic contexts using actual tools;
- design learning environments and experiences rather than selecting instructional strategies leading to specific learning outcomes;
- set open ended tasks and expect pupils to modify them;
- describe tasks using a variety of media and presentational perspectives, for example, stories, numbers, rules, statistical summaries, photographs, sound and video;
- use real raw data and primary sources, and provide a variety of analytic tools;
- allow pupils to develop their own understandings from different perspectives, that is, accept multiple perspectives;
- ask pupils to brainstorm, create, invent, question, classify, analyse and predict;
- ask pupils to elaborate their initial responses;
- direct pupils towards tasks that might help them identify errors, confront misconceptions or engender contradictions to their initial hypotheses;
- always enquire about pupils' understandings, wait for pupils to respond and accept their responses before sharing generally accepted concepts, that is, emphasise knowledge construction not reproduction;

- scaffolding is in place to help pupils perform beyond the limits of their ability in the zone of proximal development (Vygotsky, 1986);
- encourage dialogue and collaborative learning;
- encourage the development of cognitive strategies and attitudes as well as memorising verbal or factual information, motor skills and intellectual skills (Gagne, 1992);
- assess processes as well as products;
- facilitate and guide rather than instruct;
- keep an open mind, and accept that pupils will not always learn what teachers intend.

These recommendations may well be helpful, however, it is not yet clear which recommendations are essential or merely desirable. Although some case studies have been done, there is a need for more extensive study of constructivist/minimalist approaches in practice when teaching IT within the English state secondary school system. There are suggestions that constructivist approaches do not work for all pupils, for example, it may well be that socially moderated understandings accepted from the wider culture appear to some pupils as little different from facts about the external world that must be memorised; learners may become disorientated or lose the focus of their cognition and drift apparently aimlessly; 'it is unlikely that all learners are equally suited to performing their own sequencing, pacing and direction'; and less experience learners may be more at risk than advanced learners (Davidson, 1995). The minimalist boundaries between the behaviourist English state secondary school system and constructivist approaches to teaching and learning IT are not yet clearly positioned. There is an obvious need for better descriptions of a new pedagogy for teaching and learning IT that is well grounded in theory and research to help IT teachers in English state secondary schools adopt more appropriate strategies in the classroom.

Conclusion

Teaching IT in English state secondary schools is problematic. More effective training, planning and resource management might lead to improvements, however, some difficulties are exacerbated because of fundamental differences between the behaviourist paradigm that has extensively influenced all aspects of the English state secondary school system and the teaching and learning of IT. There are general characteristics of IT, and features of teaching and learning IT in English state secondary schools that make a constructivist approach the only workable methodology. A new pedagogy is needed that is theoretically sound and that guides teachers in using constructivist approaches within an education system grounded in an inimical behaviourist paradigm. This paper takes tentative steps towards an understanding of some of the problems and a resolution of some of the issues. For the present, IT teachers may be well advised to take pragmatic, minimalist approaches, in developing constructivist strategies to teaching and learning.

Abbreviations

HMI	Her Majesty's Inspector
OFSTED	Office for Standards in Education
NC	National Curriculum
TTA	Teacher Training Agency
PGCE	Post Graduate Certificate in Education
BEd	Bachelor of Education

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