The Influence of a Technology-rich Classroom Environment on Elementary Teachers' Pedagogy and Children's Learning

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Abstract

Our goal is to investigate the role of ICT within the complex inter-relationships amongst aspects of the classroom setting which contribute to young children's activity and learning. This paper focuses on the relationships between the many different features of the classroom which influence learning. These include the teacher's plans and classroom organisation, the way in which the teacher mediates subject knowledge and ICT use for pupils, the children's ICT capability, the nature of the tasks set and specific learning materials available, the software applications and digital resources available for both staff and children, and other aspects of the classroom environment.

The influence of the technology's features on teaching approaches and pupil learning was explored through classroom observation of teacher and pupil activity in the 'core' subjects English, Mathematics and Science in years 3 and 4 (aged 7-9 years), together with interviews with the class teachers. The data has been analysed using an established model for characterising ICT-based pedagogy based on teacher orchestration of the affordances and constraints of classroom resources. We set out the common features of the relationships found across the different classes, and make comparisons between subjects and classes. We draw conclusions concerning the teachers' pedagogies together with pupil tasks and classroom organisation strategies which create effective learning environments involving the use of ICT and other resources.

Keywords: elementary education, effective pedagogies, learning environments, conditions for learning, organising for learning.

1 Introduction

There is growing evidence that increasing the level of ICT resourcing in schools can have a positive effect on young children's attainment in the 'core' subjects of English, Mathematics and Science (BECTA 2001, 2002).

It is less clear how this effect is caused, however, and the UK literature to date (BECTA 2001, 2002, Kennewell 2001, Kennewell *et al.* 2000, Moseley and Higgins 1999, NAACE/BECTA 2001, NFER 2002, Twining 2002) suggests that resourcing, subject content, classroom practice all contribute, together with some other factors. These aspects are detailed in Table 1.

Resourcing
Quantity, specification and reliability of hardware and communication systems
Location of equipment
Software: systems, generic, and subject specific
Resource management
Technical support
Curriculum and pedagogical support
Content
Programs used
External materials and data sources used
Internally created materials
Structure for access to software
Structure for storing/sharing pupils' work, including access from home
Practice
Nature of computer use
Nature of tasks and level of challenge to pupils
Teachers' orchestration of features in support of work on tasks
Degree of learner autonomy in seeking information, manipulating data and developing ideas
Extent of reflective activity
Role of ICT in supporting tasks
Assessment, recognition and feedback on ICT work
Time spent using ICT
Other factors
Ethos of school
Expectations by Headteacher of ICT use
Capability and attitude of teachers
Capability and attitude of pupils
Extent of extra-curricular use
Extent of home use
System for ICT coordination
Nature and extent of professional development
Regularity of review of ICT in the school

Table 1: Factors Contributing to ICT's Influence on Attainment

If we are to identify the ways in which ICT influences attainment, it will not be sufficient to quantify and describe each of these factors in isolation and then seek correlations between them. We will need to seek explicit evidence of interaction between them, for example by investigating the ways in which:

- the nature and location of resources facilitate teachers' take up of ICT,
- teachers orchestrate ICT and other resources to motivate and support activity that is challenging to pupils;
- the nature of the learning objectives influences which ICT resources are selected and how they are used;
- pupils' ICT capability affects the way in which they are able to manage their learning with ICT.

There is a particular need to investigate the relative contributions of teachers' pedagogy and their orchestration of technology's features to children's learning, rather than merely the quantity of ICT resources or the extent of their use. Primary teachers in the UK have been found to use ICT predominantly in the following ways (presented in order of frequency):

- free choice activities for pupils;
- extension work and extra support for some pupils;
- a reward or 'filler' activity for those who have completed other work;
- word processing, information retrieval and major project work;
- instructional use with the whole class.

(Moseley and Higgins 1999: 83)

Presented out of context, these patterns of use do not convey any sense of purpose. ICT is used in the classroom with the aim of helping children to learn particular subject matter. This is expected to take place through goal directed activity in which there is a gap between the student's current knowledge and the learning objectives. This 'learning gap' is bridged through cognitive effort on the part of the learner. This effort utilises the affordances and constraints of the setting, in combination with the learner's existing abilities in relation to the subject matter to be learned, in order to complete a task. Cognitive tools such as literacy, numeracy and ICT capability may also be employed, depending on the nature of the task (Kennewell 2001). Reflection on this activity is an important aspect of the learning process, as metacognition helps to develop understanding of the underlying features and structure of the subject matter (Newton 2000).

Moseley and Higgins (1999) identified particular affordances which ICT provided in the teaching of literacy and numeracy: the capacity to present or represent ideas dynamically or in multiple forms, the facility for providing feedback to pupils as they were working, and the capacity to change the presentation of information easily. However, even teachers identified as 'intensive' users of ICT could find only around half an hour a week for each pupil to use ICT to improve literacy and numeracy. If increased ICT resourcing is to help improve standards of attainment, then devoting more time to these features would be expected to make the greatest contribution to learning.

2 Research Carried Out

In order to explore in some depth the effects of spending more time using ICT on classroom activity and learning, a project was set up in partnership with a school whose Headteacher was keen to collaborate on evaluative research. Pembroke Dock Community School is unusual in that it is a state school which was built and is run by a private company under the UK Government's Private Finance Initiative (see BBC 2001). This has resulted in a high standard of design, construction and resourcing. The school claims to be generating high attainment in relation to the socio-economic status of the intake, and the Headteacher attaches importance to the provision of an interactive whiteboard system (see Kennewell and Morgan 2003) and four networked personal computers (PCs) in each classroom, and a computer lab shared between community use and keyboard training for school pupils. The Headteacher expected class teachers to use the interactive whiteboard (IWB) and the pupils to use the networked PCs in most lessons. Another important feature of the school is the ability setting for the core subjects from Year 3 (aged 7–8) to Year 6 (aged 10–11).

During Spring 2003 it was agreed to carry out a project which focussed on Years 3 and 4, where there is evidence that children's progress slows (Ofsted 1999). Two researchers each spent one day with Year 3 and one day with Year 4. They observed four lessons in English, four in Maths, and three in Science. The teachers had been briefed that we were interested in observing typical lessons, rather than showpiece lessons. The researchers observed lessons led by each of the six Year 3 and 4 teachers, and subsequently interviewed each of the teachers.

A model for analysing pedagogical situations based on affordances and constraints (Kennewell, 2001) was used to design a format for lesson observation, and notes were made concerning:

- the nature of the activities being carried out in the class, with detail of class organisation and the demands made of pupils by tasks;
- the knowledge (concerning subject matter and resources) required to engage with the tasks;
- the features of the setting (particularly ICT) which influenced activity;
- the way the teacher orchestrated the features in relation to pupils' abilities in order to bring about learning.

Interviews with teachers were semi-structured, with questions concerning:

- the length of teachers' experience (within the current building, at the school in its previous building, and in teaching as a whole);
- their planning and preparation of lessons;
- the resources they have found and evaluated;

- the resources they have produced either for themselves or to be shared with other staff;
- the characteristics of resources that they find particularly effective for pupils' learning;
- their general feelings about the impact on pupils' learning of the new environment and technology.

The emphasis of the questioning concerned changes from the traditional classroom environment, and so it was to be expected that teachers' responses focussed on the novel IWBs, which were new to them, rather than the PCs which were more familiar.

3 Analysis and Discussion

The observation notes from twelve lessons and the transcripts from six interviews were analysed qualitatively, seeking patterns in the data under three main headings:

- Pupil ability and activity
- Features of technology
- Teachers' organisation.

3.1 Developing Children's Ability Through Activity

Each lesson adopted the same general structure, and the children's activity tended to follow particular patterns.

The first phase of the lesson involved repetition, by the whole class together, of familiar actions where full participation and joint success is expected. The second phase involved the introduction or gradual development of children's skills and concepts which require some scaffolding. This involved watching display/ animation/annotation on the board; discussing a variety of representations; interacting physically with displayed information; and responding to questions (including 'what if' questions) orally, with or without a visual display. These tasks were often carried out by an individual child in front of the class. The teacher would prompt the child in such a way that the whole class felt involved in supporting the particular pupil who was at the front.

The third phase involved further development of skills and concepts through individual activities. These were carried out manually (sometimes with supporting resources such as laminated, illustrated information sheets for reference or plastic cubes for counting/sorting) or using PCs. Some activities involved trial and improvement, some just repetitive practice; some required the construction of responses in writing, and some took the form of competitive games. Those involving use of the PC often replicated the manual version of the task, but additionally required some knowledge of ICT. Other PC tasks involved a type of action or a degree of interactivity which could only be achieved through ICT, such as the task of clicking on a grid of numbers to select those which fitted a stated criterion, and gaining immediate feedback on whether the selection was correct.

The final phase involved revisiting key teaching points and reviewing any difficulties which pupils had found. This had potential for reflective activity on the part of pupils, but was generally teacher-dominated with a lower level of pupil participation than earlier whole-class phases. This part of the lesson was partially dependent on events noticed during children's work on tasks, and so had not been planned in the same detail as the earlier phases of the lesson.

Interviews revealed other aspects of pupil activity which impacted on learning. Teachers felt that children were limited by their poor typing skills, and that their keyboard training did not transfer to their ordinary lessons. The use of word lists constructed during the whole-class phase and the process of spell-checking were seen as making positive contributions to their learning.

There was some recognition of autonomous learning. Pupils were sometimes prompted to "look for information on the Internet" (Teacher B) after they had finished other tasks, but were not always able to understand the information they obtained. Children also "pick up things at home they haven't been taught" (Teacher A).

It was also suggested that the use of ICT had helped to involve a pupil with emotional and behavioural difficulties in normal class activity. It was also a major factor in helping a child with cerebral palsy to undertake the same activities as other pupils, using considerable skill with ICT to achieve high quality results.

3.2 Features of Technology that Impact on Activity and Learning

A wide range of classroom features were involved in supporting children's learning. There were usually a number of adults in the classroom: as well as the qualified teacher and a classroom assistant, some children were allocated a learning support assistant in response to their statement of special educational need. Plentiful supplies of equipment for mathematics, science and technology were available; each classroom had a stock of fiction and reference books; the walls were covered with educational posters and displays of pupils' work.

The two main features of interest for this analysis, however, are the interactive whiteboard and the networked PCs. Table 2 shows the key features which were noted in classroom observation.

IWB
Large, clear, colourful display
Easy writing with electronic pen, but need to write quite large for class visibility
Annotation and highlighting
Range of activities can be help on task bar and/or bookmarks
Recall for recap and review
Controllable display of animated images, video etc.
Point/clicking, dragging
Prepared/generated material
Colours and highlighting to distinguish different items of text
Sound effects for attention and emphasis
Easy deletion and editing
Arrows etc from drawing menu
No use of keyboard
PCs
Choice (sometimes)
Feedback (may need ability to interpret output)
Electronic worksheets (teacher prepared)
High quality presentation of pupil work
Spell check
Editing
Textboxes to structure writing
Option of sound through headphones
No record of attainment on games

Table 2: Features of ICT that Impacted on Children's Activity in the Classroom

Teachers felt that the IWB was effective in gaining pupils' attention, keeping their attention for longer, stimulating thinking and maintaining a focus on the subject matter rather than on the teacher or other pupils.

The large visual display was generally suggested as the main factor which brought about this difference. "They seem to be more interested in the lesson again because they've got pictures, visual, they've got things there to look at, they'll stop and they'll ask and answer questions because it's there in front of them, as opposed to us just talking to them and not having anything for them to look at" (Teacher D). PowerPoint was a particularly important tool for the teacher: "It brings things over" (Teacher A).

Teachers recognised the importance of a variety of representations, particularly for difficult ideas, and the need for a number of activities in which the same skills were repeated using different examples and the same concepts were experienced in different ways. ICT activities were felt to add to the teacher's repertoire, even if they were not the most important activities.

The degree of engagement and participation was felt to be increased; this was seen as particularly important for the less able children. One way in which this was achieved was by calling pupils up to the board to interact with the material; it was important that the younger children and emerging readers were able to drag words and images as objects rather than being constrained to writing or drawing.

Use of the PCs clearly improved the legibility of children's writing. Creative writing was felt to be enhanced by the availability of borders, clipart, print quality, colour, and font size. However, teacher B felt that pupils did not write as much on the PCs as on paper, and that ICT inhibited creative thinking because children concentrated on embellishing the appearance of the text. Teachers felt that it was valuable to be able to show pupils' work on the IWB, and were eagerly anticipating a system upgrade which would enable more effective use of the features of the network rather than merely individual PCs.

3.3 Teacher Organisation of the Learning Environment

The most significant feature of teachers' organisation with ICT was the speed and ease with which material prepared in advance was brought up onto the IWB to engage pupils' interest. The material had been appropriated and developed by the teachers, and they were thoroughly familiar with the content which would appear. This detailed knowledge of the material was combined with the use of established organisational routines in order to maintain a tremendous pace to lessons. This was not a purely linear flow; teachers moved backwards and forwards through the content and process of the lesson by scrolling documents, selecting PowerPoint slides, and 'flipping' through pages of the electronic flipchart software provided with the IWBs. They also responded to points arising from the class, although this may have been inhibited by a reluctance to depart from the highly detailed planning. But that planning, together with their experience of pupils' difficulties and detailed knowledge of pupils' abilities, enabled them to select the right level of task for pupils when called to perform in front of the whole class as well as for individual work.

They interacted with the class by facing them all the time, and, aided by routines, preparation and human support, were able to orchestrate continuous engagement by the children. This seemed to be an important advance over the traditional teaching situation where the teacher often has to look away from the children or move away from the focus of their gaze in order to organise another feature of their teaching. The consequent loss of eye contact makes disruption more likely and regaining attention difficult. The high degree of engagement by all pupils during whole class teaching appeared to help in promoting strategic thinking and supported a level of scaffolding which is often hard to find in primary classrooms (Bliss *et al.* 1996). The ability to replay events and review processes helped them to promote reflection. They were also able to demonstrate ICT techniques easily to the whole class.

The teachers recognised that they devoted a lot of time to learning to use the ICT tools, to preparing lessons and to producing resources. In general, they felt their investment of time to be worthwhile because of the impact on the children's learning and behaviour. "The planning does take a lot more thought because you have to try and use the whiteboard as well and the preparation if you're doing

PowerPoint, takes a long time to look for the correct pictures. You want to be as succinct as possible when you put words up there, questioning and it's taken a long time" (Teacher B).

The time taken in planning and preparing was reduced by a high degree of collaboration between staff, both within a year group for non-core subjects, such as history, which are taught in mixed-ability classes, and across year groups for core subjects where the top set in Year 3 may be doing the same work as the middle set in Year 4. The teachers also recognised the value of re-using materials, both for recap and review with the same class, for access by individual children, and for the next year's class. They all found that in the second year of teaching in the high-technology environment, their first attempts seemed inadequate and could be improved considerably with their improved knowledge of IWB techniques. However, they perceived that their use of the technology was restricted by what they still felt was a low level of skill in using the IWB tools and limited knowledge of applying their skills to curriculum activities. There was a desire for more training, particular from teachers from other schools who had moved further forward with the new medium.

One of the main advantages of using the IWB in the lesson was that all the material was ready at the start, and so there were no gaps during the lesson and no distractions for the children whilst the teacher organised papers or put up a picture on the wall for pupils to talk about. Furthermore, the tasks for the lesson were only displayed when required. In the past, children had been demotivated by the amount of material which was written up on the traditional board at the start of the lesson.

The teachers felt that they spent the same amount of time on whole class teaching but there was more time for interaction with pupils, improved monitoring of pupils' engagement with the ideas, and hence more learning achieved. Teachers also found it easier to produce material which was differentiated for different ability levels, particularly within their mixed-ability classes.

When working on the networked PCs, teachers felt that pupils were able to work more autonomously whilst maintaining their focus on the task. There was a need to limit their autonomy, however, as the children knew how to access activities such as games and could visit unsuitable websites.

4 Conclusion

The case study school has demonstrated a high degree of standardisation of teaching approaches and lesson structure across the classes observed. This is largely a result of adopting the National Literacy and Numeracy Strategies (DfEE 1999a, 1999b), but has also been influenced by the expectation that the IWB and networked PCs are used in most lessons, and by the collaborative approach to planning which is generally adopted by primary teachers in the UK. There were some differences between subjects, with PowerPoint found especially valuable for illustrating concepts in Science, and some software tools especially designed for the IWB being used effectively in Mathematics.

It seemed that with the focus on the role of the IWB and networked PCs, lesson planning was more fine-grained and activities thought through in more detail. The range of strategies employed was perhaps more restricted than in the traditional classroom, however, as a result of their limited repertoire of IWB techniques and the perceived need to use ICT rather than other ways of stimulating interest and representing ideas.

The patterns of use established by Moseley and Higgins (1999) were all seen in this study, although there was almost a reversal of the rank order of frequency, with instructional use and word processing predominating. There was a very high level of teacher direction concerning the task to be undertaken by each pupil, although some pupil choice over the level and topic was allowed within the task when using PCs.

The reasons for emphasis on instructional use, in addition to those which stemmed from policy, were first the combination of visual and aural features which immediately gained children's attention, second the combination of the visual and dynamic features which stimulated thought and were felt to be more memorable, and third the pace of the lesson which maintained an engagement for longer than the teachers had been able to achieve in traditional classrooms. The pace of the lesson owed much to the immediate transitions between teacher activities, together with the standard lesson format, plentiful equipment, good storage and well-established pupil routines. The IWB seemed to help children to focus more on the subject matter of the lesson and less on the teacher.

Of Moseley and Higgins' (1999) affordances, it was the presentation and representation of ideas that was clearly the most important element of the IWB environment. Although the feedback and provisionality elements were seen to be exploited in the classroom, particularly with the networked PCs, these features had not been developed and incorporated into teachers' thinking to the same extent as the new whole-class multimedia tools.

Since the current UK Government came to power in 1997, they have pursued an educational policy agenda based on the improvement of standards, particularly in the core subjects. This agenda includes the whole-class teaching approach as the basis of most lessons in primary schools and the use of ICT to aid teaching and learning. These two approaches have created a dilemma for teachers who see ICT as a means of supporting the development of more autonomous learning, and thus at odds with the teacher-focussed whole-class approach. It is not surprising, therefore, that the IWB has been embraced so enthusiastically: it offers a potential resolution to the dilemma.

Prior to the widespread availability of the IWB, UK schools seeking to improve attainment levels in literacy and numeracy, particularly for the less able, had been turning to Integrated Learning Systems (ILS) for ICT solutions (Underwood and Brown 1997). These systems are based on the principle of programming the PC to take over from the teacher the setting of tasks and the orchestration of affordances and constraints to support

activity by the pupils using them, thus freeing the teacher for interaction with other pupils. This approach has produced some successes, but improvements have been too patchy to ensure widespread adoption.

With the IWB, however, teachers can instead use ICT to enhance their whole-class teaching and engage all pupils in the same activity; with a number of networked PCs in the classroom, pupils can work more independently (and at differing levels) on ideas introduced to the whole class. This combination offers real possibilities for improving standards, provided that the teachers have the time and support needed to develop their repertoire of ways of using these valuable tools.

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