How can the use of an interactive whiteboard enhance the nature of teaching and learning in secondary mathematics and modern foreign languages?

Contents

ICT Research Bursary 2003-04 – Final Report

From Technology to Professional Development

How can the use of an interactive whiteboard enhance the nature of teaching and learning in secondary mathematics and modern foreign languages?

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About the Authors

The research team, led by Dave Miller, comprises Doug Averis, Victoria Door and Professor Derek Glover.

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Dave Miller leads two other interactive whiteboard (IAW) research projects. The first – with Doug Averis and Professor Derek Glover and funded by Nuffield Foundation – is titled *Enhancing Mathematics Teaching through New Technology: The use of the interactive whiteboard* (2004). The second currently unpublished project, funded by the TTA and involving all the members of the research team, is titled *From Technology to Professional Development: How can the use of an interactive whiteboard in initial teacher training change the nature of teaching and learning in secondary mathematics and modern foreign languages?* These projects are not directly linked, but the work of each informs the work of the others.

Executive summary

Introduction
During the autumn and spring terms of 2003–04, the team video-recorded and interviewed 'best practice' teachers to ascertain the rationale, practicalities, pedagogic implications and outcomes of the use of interactive whiteboards (IAWs) in mathematics and modern foreign languages.

Aims and objectives of the study
The key question for the research is: What are the essential features of interactivity, intrinsic in the use of IAWs that make them more effective than current similar presentation media (whiteboards, overhead projectors (OHPs), computers with data projectors) and how can their use be promoted and then sustained? This would involve considering effective uses of the IAW and resources available in the two subjects, teacher-production of resources and professional development issues.

Research design and procedure
Each 'best practice' teacher was observed and video-recorded for at least one lesson, and then interviewed using a semi-structured interview format. Further evidence related to best practice was taken, where appropriate, from our other IAW research data.

The analytical framework used to interpret the video-recorded evidence was intended to build on that already in place for the Nuffield Foundation research (2004) and to extend it to include a pedagogic analysis to ascertain the link between specific use and learning, both in formal lesson planning and in response to pupil needs.

Literature review/knowledge base
A review of the increasing knowledge base provides a consideration of IAW use in terms of developments in technology and the classroom, pedagogy and the nature of interactivity.

Findings/results
Our analysis suggests a developmental approach, with teachers progressing (or not) through three stages. Although these ideas were not completely formalised at the outset of this research, there was an expectation that the teachers selected as examples of best practice would 'demonstrate' qualities that are now identified as *enhanced interactive.* The three stages of the IAW teacher are:

- **Supported didactic**: The teacher makes some use of the IAW but only as a visual support to the lesson and not as an integral tool to conceptual development. There is little interactivity, pupil involvement or discussion.

- **Interactive**: The teacher makes some use of the potential of the IAW to stimulate pupils' responses from time to time in the lesson and to demonstrate some concepts. Elements of lessons challenge pupils to think, by the use of a variety of verbal, visual and aesthetic stimuli.

- **Enhanced interactive**: This approach is a progression from the previous stage, marked by a change of thinking on the part of teachers. They now seek to use the technology as an integral part of most lessons, and look to integrate concept and cognitive development in a way that exploits the interactive capacity of the technology. These teachers are aware of the techniques available, are fluent in their use and structure lessons so that there is considerable opportunity for pupils to respond to IAW stimuli – as individuals, pairs or groups – with *enhanced interactive* learning. The IAW is used as a means of prompting discussion, explaining processes and developing hypotheses or structures; these are then tested by varied application. A wide variety of materials are used including 'home-grown' and internet resources, and IAW specific and commercial software.

The 'best practice' teachers selected for the study were all working at either the *interactive* or the *enhanced interactive* stages, with all of them demonstrating elements of enhanced interactivity. In almost all cases, they each had an IAW in their classroom and used it all the time.

It is our view that, to maximise the benefits of working with IAWs, teachers should be encouraged to work at the *enhanced interactive* level and that relevant continuing professional development (CPD) should enable them to reach this stage as quickly as possible.

Discussion

The discussion that follows adapts the format of Johnson and Scholes' (1993) PEST analysis for environmental scanning of political, economic, socio-cultural and technological aspects. Our analysis focuses on pedagogy, engagement, socio-cultural aspects and technology, and looks solely at those features of teachers working at the *enhanced interactive* stage.

Pedagogy The key feature is planning and preparation. Teachers at the *enhanced interactive* stage tended to plan for cognitive development taking account of the needs of individual pupils. They would usually use a three-part lesson structure providing sequences of activities that encourage an active, thinking approach. They tended to use clear visual representation of concepts and ideas, often illustrating them in different ways by taking into account the capabilities of the IAW. They would provide immediate feedback, either giving it themselves or through their own resources or commercial software, and would use recall of earlier work on the IAW to strengthen learning. There was a growing recognition that resources needed to be saved and stored systematically.

Many teachers reported that time was saved in marking and assessment of pupils' work because the pupil responses could be immediately assessed by the technology. They also said that, compared with other lessons, the time gained in IAW lessons meant that they could deal more effectively with the needs of their pupils.

Engagement In classrooms with an *enhanced interactive* teacher, all participants appear to be highly motivated in a circle of increased pupil attention and teacher enjoyment. IAWs add credibility and validity to the subject and the teaching. Unexpectedly a number of teachers in this sample reported that using the IAW had re-motivated them, even after substantial periods in teaching.

Our evidence now suggests that the major features that encourage pupil motivation in both mathematics and modern foreign languages – and possibly other subjects – can be classified in three ways:

- those aspects of classroom management that lead to an interactive and participatory focus on the IAW throughout the lesson
- the intrinsic stimulation provided by the combination of the visual, kinaesthetic and auditory paths to learning
- the stepped learning (concepts or new linguistic items presented in a logical way, minimising leaps of understanding) that characterises much IAW teaching and which offers constant challenges with frequent assessment of achievement as a stimulant to further involvement, whether offered as immediate feedback via software or by the teacher.

Socio-cultural aspects Pupils working with an *enhanced interactive* teacher are, constructively, often used to leading, developing or enhancing their peers' learning at the IAW. The teacher also often orchestrates teacher–pupil and pupil–pupil relationships by appropriate tasks carefully selected for their interactivity.

Outside the classroom, there is an awareness developing that the sharing of resources and ideas benefits staff and pupils alike. This has led to the devising of a variety of ways in which the same resources can been used with different groups of pupils.

Technology There are four relatively simple techniques that characterise *enhanced interactive* teachers' use of IAWs:

- drag-and-drop: matching a response to a stimulant
- hide-and-reveal: opening a response when a stimulant is understood

- matching items: using equivalent terms
- movement: to demonstrate principles.

The teachers in the sample noted that they would welcome more commercial software specifically designed for the IAW, provided that it incorporates interactivity. Where such software was used, the teachers used it effectively. These interactive internet programs were usually in a game format. Many of the teacher-produced resources resulted in lessons where the IAW was the focus of all activity, including IAW-based exercises and extension work. However, all staff commented on the time required initially to prepare new resources for the IAW.

All of our *enhanced interactive* teachers had, at the very least, good ICT skills that had been improved, often considerably, over time through the use of the IAW. This meant that they could deal with 'everyday' technological hitches that might occur in lessons. As they were continually adding to their resources, they were acquiring new skills and techniques – often in a haphazard way – from colleagues or other teachers when discussing IAW resources. Only a few had attended any IAW courses of any significance (in terms of time).

All the teachers in the study stated that they would not consider changing their IAW for an alternative interactive presentation technology.

Suggestions/recommendations

- For IAWs to have a significant impact on the teaching and learning of mathematics and modern foreign languages, teachers need to reach the *enhanced interactive* stage of development.

- To achieve this developmental stage most efficiently, priority should be given to developing appropriate CPD.

- A video for teacher familiarisation training should be commissioned so that effective training in IAWs can be made available to teachers either individually or in groups at times that suit their needs. In this way, familiarisation can be widespread and effective.

- Schools and departments purchasing IAWs should take the training needs of their staff into account, and provide sufficient resources to allow them to be trained.

- There are considerable advantages in moving forward a number of teachers in the same department together. A critical mass of teachers working together in one department, with the same make of IAW, is likely to make more significant progress than a number of teachers using different IAWs in a number of departments.

- At the time of purchasing an IAW, the buying of subject-related software specifically written for the IAW should also be considered wherever possible. However, care should be taken to ensure that the software supports enhanced interactivity. Having such software will help reduce the initial time taken by all staff in preparing their own resources.

- Consideration should also be given to the purchase of other appropriate subject software that might also support enhanced interactivity and be used effectively on the IAW. In mathematics, we would suggest a spreadsheet, a geometry package, graph-plotting software and short programs.

- Teachers will undoubtedly continue to produce their own resources, but staff should work together as a department, paying due regard to the storage and retrieval of individual and departmental resources.

- In preparing resources teachers should take into account the constraints of workload and the ability to work effectively and efficiently. They should endeavour to produce materials that

enhance interactivity, primarily using the IAW as a means of prompting discussion, explaining processes, developing hypotheses or structures and then testing these by varied application.

- Making resources available to pupils out of lessons, through printouts of screens or allowing internet access, is still in its infancy, but may be an appropriate way forward.

- With regard to the purchase of IAWs, *The Good Guide to Interactive Whiteboards* by the Review Project (2004) should be consulted.

How can the use of an interactive whiteboard enhance the nature of teaching and learning in secondary mathematics and modern foreign languages?

Introduction

Many secondary schools are investing in interactive whiteboards (IAWs). We know that it takes time for teachers to learn how to use them effectively and that some teachers stop using them because time or technology issues 'defeat' them. It is also our belief that a number of other teachers use IAWs in ways that make little use of their technological features. In these cases, IAWs are poor value for money. To maximise the chances that IAWs will become excellent value for money, this research seeks to establish guiding principles that might increase the likelihood of IAWs being used more effectively, more quickly and by more teachers.

During the autumn and spring terms of 2003–04 the research team took part in extensive work to ascertain the rationales, practicalities, pedagogic implications and outcomes of the use of IAWs in two subject areas: mathematics and modern foreign languages.

The intention was to video-record teachers – identified as those who might 'demonstrate' best practice – teaching typical lessons using IAWs. These teachers would also be interviewed.

Policy framework

The effective use of IAWs is clearly an important and timely national issue. Considerable sums are now being invested directly by the Government – for example, £50 million in the two years to 2005 – and by schools as, for instance, part of bids to become specialist schools.

Aims, objectives and background to the study

Key research evidence suggests that IAWs can have positive effects on teaching and learning (Becta, 2003). Glover and Miller (2002, 2001a, b, c) have reported on the use being made of the technology in both primary and secondary schools. They have shown that, where teachers are aware of the ways in which IAWs can be used to support a variety of learning styles, their use promotes pupil interest and more sustained concentration, and leads to more effective learning. However, the evidence also shows that it takes time for teachers to learn to use IAWs effectively, they have difficulty finding appropriate materials to use with them and they often fail to appreciate their full potential. In addition without appropriate training, support and advice, IAWs tend to be employed in a way that replicates the use of more traditional presentational media – whiteboard, overhead projector (OHP), computer with data projector – thereby failing to exploit the power of interactivity.

However, Greiffenhagen (2000) hoped that, as teachers got more experience with IAWs, this technology might be used 'so that [it] might provide innovative resources for teaching and learning'. Simpson et al (1998) and Colley et al (1998) have demonstrated the use of interactive technology within specific subject areas and stressed the need for changed approaches to teaching methods, subject by subject, basing pedagogy on staged learning processes, the availability of stimulating materials for all learning styles and the possibility of integrating a number of approaches. There is also a growing body of theoretical analysis, such as that of Ligorio (2001) who has looked at the way in which a variety of learning styles can be built into materials.

Our Nuffield Foundation funded research work (2004) has already helped us to identify some elements of a new pedagogy. This emerges where teachers are more deeply aware of learning processes and the need to plan to meet the diverse learning styles within any group of pupils. The intention of this research is to seek examples of the use of IAWs, in the areas of mathematics and modern foreign languages, where teachers are using them to exploit the power of interactivity to

enhance pupils' learning. In this way, we can improve our understanding of the learning process with IAWs and consider how best to promote continuing professional development (CPD) in this context.

Therefore, the key question for the research is:

- What are the essential features of interactivity, intrinsic in the use of IAWs that make them more effective than current similar presentation media (whiteboard, OHP, computer with data projector) and how can these be promoted and then sustained?

Questions subsidiary to this one are:

- How can the IAW be used in ways that are more effective than the current use of other presentation media?
- What should one look for in commercial or other available IAW materials to maximise any benefits of its use?
- What type of materials should teachers be producing for themselves, given the constraints under which they are working?
- In this context, which model of CPD best supports the growth in the effective use of IAWs in the classroom?

Research design and procedure

The 'best practice' teachers who were selected to be video-recorded and interviewed were identified by the team's established networks, including subject associations, local authority advisers, tutors in higher education institutions and HMI and other researchers working in the use of IAWs. In total, 13 of teachers of mathematics and 13 teachers of modern foreign languages were originally selected, but illness meant that three of the mathematics staff had to withdraw before any observation could take place. Hence, our sample consisted of 10 mathematics teachers and 13 modern foreign languages teachers, which was considered appropriate given the constraints of time and funding.

Each teacher was observed and video-recorded for at least one lesson, some for more; how much usually depended on logistical factors. In addition, each teacher was interviewed using a semi-structured interview format. Further evidence related to 'best practice' was taken, where appropriate, from our other IAW research data.

The analytical framework used to interpret the video-recorded evidence was intended to build on that already in place for the Nuffield Foundation funded research (2004) and to be extended to include a pedagogic analysis to ascertain the link between specific use and learning, both in formal lesson planning and in response to pupil needs. The intention was for the analysis to include reference to:

- definitions and elements of interactivity
- balance in the use of presentation and learning techniques
- opportunities for interactivity in lessons (starter, main, plenary, etc)
- profiles of effective practice in pedagogy in terms of elements of interactivity (use of colour, drag-and-drop, hide/reveal, reprise, etc)
- teachers' perceptions of the learning process in action
- criteria for selection of software for use on IAWs
- advice for teachers who wish to produce their own materials and examples of simple, but effective, materials
- histories of experience and how the teachers have 'learned' to become effective practitioners
- CPD requirements.

As outcomes of the Nuffield Foundation (2004) and TTA funded research (unpublished) and of this study, we would expect to produce:

- 'action outlines' for using IAWs in mathematics and modern foreign languages in terms of the preparation and use of resources and teaching
- a report that provides examples of professional development to enable teachers of mathematics and modern foreign languages to make the transition to a new interactive pedagogical insight
- a brief report that suggests areas for further research and details issues for policy-makers
- such professional and academic articles as may emerge.

Literature review/knowledge base

There has been a recent, and considerable, investment in the installation of IAWs in schools in the United Kingdom. In part, this has been a response to government pressure for enhanced understanding and use of information and communication technology (ICT) and to finance within the education system to support purchases of such equipment. It is also partially a reflection of more widespread understanding among teachers of the value of interactive learning. This was demonstrated by, for example, McCormick and Scrimshaw (2001) in their analysis of pedagogic change in the teaching of mathematics, and by Glover and Miller (2002) in charting change within one secondary school.

Teachers in both initial and continuing teacher training are now made aware of the technology and its potential for enhancing teaching effectiveness in a range of subjects, but there has only been specific work in some subject areas. This includes:

- Glover et al (2003) and Edwards et al (2002), who have summarised the impact on mathematics teaching in a number of secondary schools
- Cooper and Brna (2002) and Blanton and Helms-Breazeale (2000), who have shown how pupil motivation and understanding can be fostered in those with special educational needs (SEN)
- Ekhami (2002), who has reviewed the technology's use in literature appreciation
- Smith (2001), who has shown the gains to be made in primary teaching.

These research reports largely focus on the way in which presentation is improved, pupils are motivated and learning is enhanced during the early stages of the use of the technology. Other observers have raised concerns that the IAW could be just another presentational gimmick. In managing this, McCormick and Scrimshaw (2001) have demonstrated the need for a rapid movement along a continuum from more attractive presentation of materials, through sustained pupil motivation, to the achievement of sustained and interactive learning approaches by the teachers involved.

It is this element of interactivity that is now recognised as the key to both learning and sustained interest, as indicated by Birmingham et al (2002), and by Buckley (2000) working within the field of biology education. But what do we mean by interactivity, and how is it to be fostered? Robison (2000) and Jones and Tanner (2002) offer confirmation that sustained interaction between teacher and taught is fostered through effective questioning rather than via a wider range of activity. Our work has provided evidence of this, where some lessons with older pupils have incorporated one or two concepts for the whole lesson, but the work has had heightened pace and interest. For Sabry and Baldwin (2003), the emphasis is on web-based learning and is more individualised.

There is an extensive literature on the techniques that can be used in association with the technology, but most of this stems from work in higher education. Berque et al (2000) note the advantages of linking an IAW with student lap-top computers, while Flatley (1996) considers the ways in which the link to the internet can enrich classroom teaching through the IAW. Linking to the internet has been assessed for its impact in securing higher education cost advantages in colleges (for example, Sugar and Boling, 1995) and across subject areas (for example, Lim, 2001).

Research reports on pedagogy offer many examples of the ways in which the IAW has been used. These include general coverage such as the Becta Research Reviews (2003), and specific subject application. Examples of the subject specific application of IAWs include literacy (DfES, 2001), modern foreign languages (Gerard et al, 1999), social science teaching (Elvers, 2000) and music education (Wiggins and Ruthmann, 2002).

The use of new technologies has its drawbacks, however. Hanisch and Strasser (2003) consider the trade-off between time taken to prepare materials and the learning effectiveness that accrues. However, Harler (2000) shows that the latter can be enhanced by 'printing off' and saving all materials used and developed, including video clips and internet hyperlinks. Carr (1999) considers whole-class use of the IAW and the pressures this may put on the teacher. Young (2002) provides a useful bridge between the technology and pedagogy involved by stressing the importance of in-built interactivity to secure changes in teaching and learning.

Other research evidence points to the gains to be made from IAW use. Blane (2003) examines the effect on pupil motivation in the primary classroom. Mauve (2003) looks at the way in which pupil–teacher interaction can be helped through the use of individual pupil slates, and points to the immediacy of assessment that results. Clemens et al (2001) describes the gains from the IAW when used to enhance the learning of slower learners, and Bell (2000) describes attempts to use the technology to help those with literacy learning problems.

All of these look at the way in which the IAW can be used to support pedagogy through interactivity. However, few authors deal with the specific nature of interactivity. Damcott et al (2000) measure the learning gains made from the visualisation of concepts. Murphy et al (1995) analyse the methodology required for student use of IAW-based data. Nonis and O'Bannon (2001) deal with the requirements of questioning and involvement where the IAW becomes the focus of the lesson. Olive (2002) stresses the need for an active style of teaching and learning based on constructivist principles so that conceptual learning contributes to cognitive understanding.

The link between pedagogy and practice has led to further exploration of the way in which interactivity can assist learning. Latane (2002) has demonstrated that interactivity with all technologies needs to be pupil–pupil as well as teacher–pupil. Glover and Miller (2002) have indicated the need for immediacy of response and the opportunity to explore ideas as an adjunct to enhanced presentation of material. Iding (2000), working in initial teacher education (ITE) for scientists, has shown the need for the co-ordination of pictorial, textual and audio materials. There has, however, been little attempt to develop sequentiality and extended coherence of understanding – interactivity has been seen as an aid to traditional classroom teaching rather than as the driving force for understanding.

The computer is increasingly part of the everyday armoury of the teacher and of many pupils, and ICT is regarded as a key skill underpinning all subject areas. However, unless connected to a network with individual or paired use of machines, it has serious limitations as a group teaching tool. This is because the technology may well be more attractive to the individual than the content of the teaching, and because computer screens are too small to allow full-class participation. More than this, it requires us to reconsider the way in which the technology available to us as part of our pedagogy is used. Guimaraes et al (2000) express the necessary changes in the following way:

> The human mind seems to work like the World Wide Web, in a dynamic, creative, fractal and unpredictable way. But when designers [of software] attempt to support the user, options are often un-engaging and ineffective. Once an author or designer abandons the notion of total control over the learning material and instead engages the audience in a process of co-construction, a more fundamental question surfaces: can the learning material become organic, adaptive and generative?

The IAW has provided an answer to this because it can promote flexibility, sequentiality and reinforcement in the learning process as well as the matching of learning to pupil learning styles. Without this, it is possible that, like the language laboratories of the 1970s and 1980s, the new technology will be installed and then neglected once it has lost its novelty value (Malavet, 1998,

Greiffenhagen, 2000). Best practice requires that the pedagogic gains are seen to be such that a reversion to conventional learning is no longer tenable.

There has been limited research into the necessary pedagogy to enhance the effectiveness of IAW through interactivity. Glover and Miller (2002) and Glover et al (2003) have shown that teacher attitudes can inhibit or enhance the learning experience, and McCormick and Scrimshaw (2001) offer a similar model based on the ways in which technology is used. While the desiderata of interactive materials has been explored (Birmingham et al, 2002), there are as yet only limited software packages available in the full range of subjects.

Deeper involvement in the meaning of interactivity has been directed towards either the developing inter-relationships between teacher and taught (Birmingham et al, 2002) or the conceptualisation of the learning process and the way in which it can be developed, as explored by Buckley (2000). Jones and Tanner (2002) have looked at the implications for classroom management so that interactivity is encouraged. Maor (2003) has considered the importance of changing teacher activity so that learning becomes much more active and, subsequently, more cognitive through enhanced reflection.

Findings/results

The findings described here are informed by:

- the data from videos and interviews associated with this Becta funded project
- further video and questionnaire data collected for the Nuffield Foundation funded research, analysed for evidence of effective practice in the use of the IAW
- reflective discussions with the Nuffield Foundation funded research participants and within the team itself.

Our judgements have also been informed by our professional development work in thinking skills in mathematics – in particular, the Cognitive Acceleration in Mathematics Education (CAME) project.

Our analysis suggests a developmental approach with teachers progressing, or not, through three stages. Although these ideas were not completely formalised at the outset of this research, there was an expectation that the teachers selected as examples of ‘best practice’ would ‘demonstrate’ qualities that are now identified and referred to as *enhanced interactive.*

The three stages of the IAW teacher are:

- **Supported didactic**: The teacher makes some use of the IAW but only as a visual support to the lesson and not as an integral tool to conceptual development. There is little interactivity, pupil involvement or discussion. Typically the IAW illustrates rather than involves, and only limited materials are developed with its tools or software or, occasionally, with PowerPoint. The IAW remains a novelty to pupils.

- **Interactive**: The teacher makes some use of the potential of the IAW to stimulate pupils’ responses from time to time in the lesson and to demonstrate some concepts. Elements of lessons challenge pupils to think, by the use of a variety of verbal, visual and aesthetic stimuli. Typically the IAW is integrated into teaching and learning, further materials are developed and more varied software is evident in lessons. At times, technological fluency results in a ‘fallback’ to conventional teaching, but despite this, the IAW is seen as a normal feature of lessons.

- **Enhanced interactive**: This approach is a progression from the previous stage, marked by a change of thinking on the part of teachers. They now seek to use the technology as an integral part of most lessons, and look to integrate concept and cognitive development in a way that exploits the interactive capacity of the technology. These teachers are aware of the

> techniques available, are fluent in their use and structure lessons so that there is considerable opportunity for pupils to respond to IAW stimuli – as individuals, pairs or groups – with enhanced active learning. The IAW is used as a means of prompting discussion, explaining processes and developing hypotheses or structures; these are then tested by varied application. A wide variety of materials are used including 'home-grown' and internet resources, and IAW specific and commercial software.

The 'best practice' teachers selected for the study were working at either the *interactive* or the *enhanced interactive* stage, with all of them demonstrating elements of enhanced interactivity. In almost every case, these teachers had IAWs in their classrooms and used them all the time.

It is our view that, to maximise the benefits of working with IAWs, teachers should be encouraged to work at the *enhanced interactive* stage, and that relevant CPD should enable them to reach this stage as quickly as possible.

Discussion

The discussion that follows adapts the format of Johnson and Scholes' (1993) PEST analysis for environmental scanning of political, economic, socio-cultural and technological aspects. Our analysis focuses on pedagogy, engagement, socio-cultural aspects and technology, and looks solely at those features of teachers working at the *enhanced interactive* stage.

Pedagogy

Planning and preparation

There was a general view among those interviewed that, when the staff have the time to develop their materials with access to appropriate technological support, it was possible to use the IAW to generate efficient and more effective learning, with tighter planning and the implementation of lesson plans according to the need to cover the prepared material.

Planning for lessons Being able to plan lessons in advance in great detail (irrespective of the source of material) allowed teachers greater freedom to attend to individual needs during the lesson, having confidence in a logical and well-presented teaching and learning sequence. By 'effective teaching', we mean teachers being able to depart from the prepared 'script' (Stables, 2004) and use fresh screens to explain or discuss issues that may have arisen. Furthermore, the pace that was generated by such planning left less time for behaviour issues to emerge, with pupils apparently on-task for significant proportion of lessons.

Planning for differentiation This strategy of pre-planning also allowed teachers to plan for activities that would involve all pupils. For example, through the use of scaffolded conversation cues in modern foreign languages, supported work on role-play or dialogue was possible, leaving the teacher free to circulate, to help individuals where necessary and to intervene to prevent a possible escalation in behavioural problems. This was closely linked with the amount of teaching and learning that can happen in a lesson:

> When we are teaching, there is now much more intervisibility, and we can give constant support from the front of the room with more focus on the task because of reduced amounts of paraphernalia. As a result, there is no get-out for the invisible child, and progression is maintained for everyone. (Modern foreign languages teacher).

Materials can be used in a way that can be differentiated on the same IAW – although not perceived to be obviously so by the pupils. For example, in modern foreign languages in a range of staged examples, some are noted as extension material to act as a spur to all pupils.

There was frequent reference in the interviews to the need to match materials to the needs of the pupils, and that some differentiation of task, activity or outcome required teachers to be 'flexible', 'adaptable' and, according to one mathematics teacher, 'aware of the ways in which consolidation can occur without going back to old-fashioned practices such as copying'. This was illustrated both in the use of a 'fraction wall' and in work on 'tethering the goat in the garden' with different ability groups. In the latter, the same visual stimuli appeared, but in one group, easier numbers were used and concepts were delivered at a slower rate to ensure that they were understood and retained.

A similar comparison can be made between two language groups that were learning and applying clothing vocabulary. Both used similar screens of information, but the more able group moved on to determine the difference between summer and winter clothing.

Teachers mentioned that they felt much more in control of what was happening than in a normal classroom because they could walk round looking at pupils' work in progress. Recalling material meant that issues arising from the teaching material or topic could be dealt with, thus giving pupils' queries more time and attention. This also seemed to indicate to pupils that their appropriate contributions and queries were valued. The teachers at the *enhanced interactivity* stage had this element of flexibility and capitalised on such queries.

The print-off facility meant that deviations from the script could be recorded. A modern foreign languages teacher said:

> I use fewer worksheets because we can print off anything that they might need, and I can give all the class more attention and still move around. Pupils move more, too. I can hand it over to them.

However, for a number of reasons, some managerial, the facility to print off resources, is, we believe, under-used even by teachers at the *enhanced interactive* stage.

In mathematics, the technology generally supported a lesson structure based on:

- an introduction or starter
- a developmental phase, or main activity, based on a sequence of learning incidents
- a plenary to review learning and contribute to metacognitive learning of the subject.

This is very similar to the lesson structure developed within CAME (Adhami et al, 1998). There was a less formalised framework in modern foreign language teaching, but in the great majority of the lessons observed, the starter, development and review structure was evident.

Awareness of the three elements – starter, development or main activity, and plenary or review – appears to give teachers a framework for lesson preparation. According to one mathematics teacher, this ensures that each lesson is planned to:

> take advantage of what the board has to offer and link that to the way in which kids learn. So although it has taken longer to plan the lessons, I am sure that they are now properly planned because I ask myself four questions:
>
> - What is my aim?
> - What are my objectives?
> - How can I use the whiteboard?
> - How can they use the whiteboard?

This mathematics teacher used this structure to underpin much of her work by 'trying to incorporate a verbal explanation, a visual example, kinaesthetic learning through movement . . . and then trying to make it relevant to their daily lives'. This process was also clear in modern foreign language teaching, where a pattern emerged of seeing pictures and learning-associated vocabulary together with sound and spelling and repeating their use in sentence construction. This was nearly always shown with

great visual clarity on the IAW, which was combined with the kinaesthetic experience of pupils coming out to the IAW and moving language items. In the plenary or review, the teachers also drew attention to the clear match of objectives to activities and the need for pupils to use IAWs to help them evaluate their progress.

Marking and assessment
Assessment procedures were developed alongside the lesson plans and, as such, evolved in step with them to meet the changing need and context. In one lesson, marking time was minimised because a series of screens on the IAW were used to check homework, allowing pupils to self-mark quickly as a group while the teacher circulated in the classroom.

The potential to save any work created on the IAW meant that ideas that were built up stage by stage in a lesson could be recorded and then printed out for pupils who may have missed the lesson or for those who needed some extra help. In addition, teachers found it helpful that the work could be saved and made available for the next lesson, when it could be used as a new starting point.

Storing and editing lessons
Using an IAW all the time meant that teachers eventually had to think about how to save and store lessons so that they could find them again. This tended to be overlooked early on, such that lessons were stored non-systematically and with unhelpful filenames. Generally, once teachers realised that this was an issue, they tended to store lessons in one of three ways:

- catalogued by topic and then drawn out as each lesson was prepared
- catalogued by lesson and then copied if the same screen was to be used in another lesson
- catalogued by intended year group and then developed with further material if used in a different context.

It was evident that teachers saw the benefits of saving lessons as the basis of future planning. This meant that basic lessons could be refined from class to class or from year to year in the light of changing pupil need and context. The most effective teachers had material stored in such a way that they were able to access it quickly within a lesson, responding to the needs of the class at that moment. As one mathematics teacher said: 'I see the IAW as a means of preparation, teaching, evaluation and future planning because everything is coded, saved and annually revisited.' Teachers recognised that changes often needed to be made, but still saw saving lessons as a major benefit to them.

Teaching style
The most effective teachers argued that the nature of their teaching had changed because the IAW offers a different potential from that of traditional equipment. Other equally effective teachers contended that they had always tried to teach in an interactive way, but had been limited by a lack of available equipment. They noted that the IAW suited their existing approach to teaching, and that they were able to extend and develop their approach by using the technology. There was also a consensus among all these teachers that they had not fully explored the potential of the IAW and were on a learning curve.

It is clear from our observations and discussions that it is still quality teaching that ensures progress; the IAW alone does not guarantee it. For example, comparison was made of two lessons of vocabulary development with Year 7 groups. In one, seven screens were used in the course of the lesson, but this was interspersed with pair work, a brief exercise and a discussion about rooms in a house. The pupils were animated throughout. In a comparable lesson, again with seven screens used, the teaching approach was much more didactic. There was little variation in activity from one stage of the lesson to another, and the inter-relationship between teacher and pupils was authoritarian and defensive. In such circumstances, the lesson would not have the vigour and 'fun' element shown in the first example.

Awareness of learning styles
In our sample, there was a high level of teacher recognition that pupils learn in different ways. One of the most effective language teachers said:

> We enjoy both teaching and learning more . . . You can give clearer examples which are more interesting because of access to colour and clip art. It's more aesthetically pleasing and is good for visual and kinaesthetic learners, and it's useful in that you can jumble up sentences and get them involved in reconstruction.

Planning for cognitive development
A striking feature of enhanced interactivity was the way in which the IAW was being used to underpin lesson structure and to enhance the way that pupils were thinking and the development of their mental powers.

For example, objectives were set, with or without revisiting earlier IAW slides. Then a bright and lively starter would be used to stimulate interest, to offer a chance for brainstorming as a bridge to the main part of the lesson or to revise necessary associated learning. The starter might build from a previous lesson, or be an associated but free-standing one, enhancing a particular skill or vocabulary, or might simply be revision of the previous lesson.

In the main part of the lesson, where the IAW was the focus of much activity, it was effectively used to give clear models in illustration, explanation, sequencing of ideas and the development of main principles. In general, mathematics lessons were characterised by stepped learning, as principles were outlined, applied and demonstrated. In the languages lessons, the progression was similarly built up in small steps, through the introduction or revision of vocabulary and then building up to its application in sentences, which was then reinforced by practice and comprehension.

During this section of the work, the most effective approach was through challenged responses in mathematics –'Why?', 'Show us/me', 'Do you think it will work?' and 'Explain' – and then the working of examples either individually or in groups. In modern foreign language teaching, the emphasis was on presentation, practice to see the extent of understanding, sensitive error correction and then practice in the completion of sentences on the IAW, reinforced by group activities. In this logical and small-stepped way, as one mathematics teacher noted, 'you move the pupils with you'.

Lessons concluded with a plenary session involving recall of earlier examples and previously worked material to ensure understanding and form the basis of extension work. In mathematics, this was usually achieved by retracing steps to ensure understanding and then posing a cognitive question as both a conclusion and a bridge to the next lesson. In languages, this section of the lesson was more usually concerned with revisiting vocabulary and structures and then looking at an associated screen requiring comprehension or conversation (and possibly transfer of learning) as a consolidation for the lesson. In most cases, the ability to go back to work done earlier in the lesson was important.

Awareness of the need for cognitive development and the place of concepts within this was shown in mathematics in the frequent reference to the sequencing of ideas, the availability of a range of pre-prepared examples appropriate to 'age and ability', and the adaptability of materials to allow for 'alternative approaches and the use of different ways of learning'. The equivalent structure in languages ranged from vocabulary recognition and pronunciation, through phrase and sentence construction, to use in verbal and aural comprehension.

Clear visual representation of concepts
Teachers commented on the particular advantages for some pupils who need reinforcement through the presentation of data or processes in more than one learning style. However, the observed lessons showed that all pupils appear to gain from the use of IAWs. We believe that this may be because they appreciate the visualisation of structures in both mathematics and modern foreign languages in contrast to more verbally dominated approaches alone (Caviglioli et al, 2002).

This is not to say that, in both subject areas, visual support is not given, but the ease of visually demonstrating principles on an IAW encourages teachers working at the *enhanced interactive* stage to use it more. Animation of material – for example, rotation in mathematics, and verb endings flying in to join verbs in modern foreign languages – is 'easy' on an IAW. It does not have to be limited to animation produced by software (for instance, PowerPoint) but can be manipulated by the teacher or the pupils themselves.

Interactivity does not necessarily have to involve pupils going up to the IAW. For example, a lesson on vectors in mathematics, during which pupils were largely working from their desks, was not overtly interactive. But it was interactive in that the teacher moved stage by stage through translation (starting with a diagram) and then to movement and then to identification of similar vectors, using the

IAW in a way that facilitated pupil understanding. In modern foreign languages, a Year 10 German lesson exploited the IAW to build up and then analyse sentences in terms of constituent vocabulary, constructional frameworks and comprehension. At the same time, a teacher gave continual enthusiastic encouragement while constantly referring pupils back to earlier screens.

Activities that encourage an active, thinking approach
In both subject areas, it was clear that teachers were using the learning of concepts as a basis for cognitive understanding. As a result, the most effective language and mathematics lessons observed by us had discernible cognitive aims plus a series of activities to explore, develop, explain and reinforce subsequent understanding.

This is how one modern foreign languages teacher summed it up:

> Sustained learner interest works at a number of different levels. It is not just a gimmick . . . the interaction is important, like kids coming out to the IAW, having choices – [for example] they can decide on the verb ending, find the stem and match up the right pronoun. It makes concrete in their minds how the language works.

Progression
In the best lessons, there was a continuing upward progression in learning and attainment. Two examples demonstrate this.

In one mathematics lesson, the teacher began by putting the aims of the lesson on the IAW and used these as the pegs on which activities were to be developed. Different methods of assessment were employed at the conclusion of each learning stage, so that 'pupils get a continuing spur to go further, a check that they have understood what they have done, and a set of targets towards which they are working' (mathematics teacher).

In a Year 7 French lesson, the teacher used a 'slick' introductory activity based on naming colours, then moved to five vocabulary development exercises and finished with a learning check. This last was scored as boys versus girls to ensure that the momentum was maintained and all pupils took part. Visual stimulation was used to the full, with a total of 10 screens during the 35-minute lesson. The dynamism of the teacher who, for example, broke up the planned activity with a two minute march to the French alphabet to stimulate the renewed activity of the pupils, was important in supporting continuing learning throughout the lesson.

Illustrating concepts in different ways
Over-writing on the IAW was seen to offer scope for assisting cognitive and conceptual development by 'showing the same thing in different ways', 'opening up an argument to ensure that it was understood' and 'overcoming the tedium of copying rules and processes' from the conventional blackboard.

The importance of sequencing
Research shows that the way teachers structure the material or ideas that they are presenting is crucial to motivation (Brophy,1998). Learners are encouraged by easy identification of key concepts, and prefer being clearly led to understand complex concepts rather than having material 'dumbed down'.

Additionally, it appears that pupils appreciate the value of the IAW when it is a source of further material for comprehension, or when it is used to demonstrate grammatical rules in action. The IAW's use as the focus of the lesson – with pupils working with their own whiteboards and coming up to the IAW to produce answers, illustrate concepts and explain processes – relates to motivation and concept development, 'giving power to the learner so that he or she takes the group forward' (mathematics teacher).

Immediate feedback
The possibility of immediacy of feedback – either through programmed software or through the use of presentational tools such as with the colours program in French or with symbols for right and wrong

answers – may aid pupils' conceptual development and be thought of as desirable by language learners (Cathcart and Olson, 1976, Chenoweth et al, 1983).

These programs can be most effective as starter activities or for work with the least able, when rapid responses and moving on can enhance number and word manipulation. In addition, when used by a teacher at the *enhanced interactive* stage, they can lead to worthwhile discussion and explanation during any part of a lesson, especially when prefaced with 'What will happen if I enter this?'

Verbalising – telling others how something works and why – is thought to aid conceptual development and a key strategy was to get pupils to explain, illustrate and direct from the IAW and so verbalise what they had been learning. Because of the facility of virtual manipulation, where pupils can move items on the IAW, this was regarded as being easier to do and far more effective than other presentational means, and teachers were more likely to ask pupils to do it.

Recall to strengthen learning
The most effective teachers emphasised the importance of recall from lesson to lesson as a means of sustaining pupil understanding and achievement. As one mathematics teacher noted:

> Recall from lesson to lesson is helped by the use of previous screens . . . Emendations and amendments are all recalled quickly, and personally, I gain because PowerPoint files are available from home using Digital Brain.

Engagement

Motivation
The enthusiasm of teachers about the potential and actual uses of the technology appears to have a spin-off effect onto classes. According to evidence from the research, teachers found preparation and delivery more interesting and enjoyable when created on the IAW and associated software. Unexpectedly, a number of teachers in this sample reported that using the IAW had re-motivated them, even after having taught for a substantial length of time.

Although we did not explicitly interview pupils, it was evident that they too, were positive in response to the enhanced interactive delivery. There appears to be a circle of increased pupil attention and teacher enjoyment. However, the teacher is vital to the process and simply having an IAW in the classroom is not in itself sufficient to create such a circle.

The evidence collected shows that less time is wasted and there is more pace in lessons with teachers at both the *interactive* and the *enhanced interactive* stage than in conventional lessons. If there is one single motivational factor during lessons, it appears to be that immediacy of response ensures maintained interest. Sixteen of the teachers referred to the greater engagement of pupils in lessons, and seven mentioned ways in which the use of IAWs encouraged participation.

Perhaps one comment from a pupil, quoted by a mathematics teacher, sums up the impact of the IAW on pupil motivation. After a lesson in which the stages of equation-solving were developed in three different ways, she said: 'Oh, my God, it's so easy when you put it like that – and I won't forget again.'

In our Nuffield Foundation funded research, when pupils were asked to identify why lessons with an IAW were of greater interest than traditional teaching, they identified:

- the inherent interest in colour, shading, dynamics, hide-and-reveal and demonstration
- the sequential development of ideas and exemplars resulting from pre-prepared and commercial software
- the availability of games that support learning – for example, team races or noughts and crosses – which require responses that can be immediately assessed and then linked to a scoring system
- the 'fun' arising from the use of such tools as compasses, grids and lines

- the immediacy of response arising from any processing built into software
- the opportunity to revisit earlier concepts and examples to underpin understanding.

Our evidence from this research work now suggests that the major features that encourage pupil motivation in both mathematics and modern foreign languages – and possibly in other subjects, too – can be classified in three ways:

- those aspects of classroom management that lead to an interactive and participatory focus on the IAW throughout the lesson
- the intrinsic stimulation provided by the combination of the visual, kinaesthetic and auditory paths to learning
- the stepped learning (concepts or new linguistic items presented in a logical way and so minimising leaps of understanding) that characterises much IAW teaching and which offers constant challenges, with frequent assessment of achievement as a stimulant to further involvement, whether offered as immediate feedback as part of software or by the teacher.

Some gender-related issues associated with motivation were observed. It was noted in the observed lessons that boys were generally more ready to demonstrate or complete work at the IAW than girls of the same age. Older boys were particularly more likely to demonstrate work at IAWs – partly, we believe, because it provided opportunities for them to show their superiority in technological fields. By contrast, girls were more concerned about 'being right' before they would commit themselves to an IAW. However, a larger study may show that this is not the case with all pupils.

Credibility and validity
Higher standards of presentation with IAWs mean that both the teacher and the subject have more credibility, due to the advanced nature of the supporting technology. The IAW also has credibility for pupils, in that it is a similar medium to that used and watched by them in their everyday lives, though on a much larger scale. Clarity of presentation and logical sequencing also appear to be motivational.

Classroom focus
A strong focus on the IAW – which combines attractive visuals with a cogent and comprehensible exposition of the teaching point – appeared to relate to increased pupil attention and a positive attitude to learning, thus minimising behavioural management issues. This was usually combined with the teacher's intention to maximise the number of pupils working at the IAW. In this way, pupils could develop their own self-esteem by using the IAW, which might stimulate the rest of the class to take part in what was happening at the IAW. Here, classroom management links closely with motivation, where pupils are offered the chance of increased ownership of lessons. This happened when teachers exploited a 'different type of contact with the lesson in the pupils' hands' (mathematics teacher).

The clear focus provided by the IAW, if used effectively, seemed to support pupils' understanding reducing the behavioural problems that spring from frustration and the 'switching-off' that can result from not being able to keep up with the lesson.

Pupils coming to the IAW
Interview respondents identified tension between teachers who thought that the time it took to manage individual pupils working directly at the IAW was a loss to active learning and those who felt it was of great value. In 15 observed mathematics lessons and eight languages lessons, this potential problem was resolved by pupils being given tasks alongside the work being illustrated on the IAW so that everyone was active.

Socio-cultural aspects

Social interaction
A feature that came as a surprise to some teachers, but was soon picked on and exploited, was the interaction within a class when a pupil was working at the IAW. In the best lessons, there was intense interest in what a pupil did on the IAW, and it appeared that the whole class would be discussing and

actively following what was on the screen. This phenomenon was observed in both subject areas and seems to confirm the existence of mediation of learning by peers and teacher as noted in the CAME work.

> It enhances collaborative work. This may just take the form of kids shouting out, correcting each other – say, in a multiple-choice selection. This is very noticeable. As the teacher, you, too, are working in a community, where you are visible. It does give a sense of competition, of expectation, the idea of 'Can you beat it?' (Modern foreign languages teacher).

Working together, in a department, inter-departmentally and across schools
The interview evidence suggested that many schools are now developing strategies for joint preparation of materials and for saving materials within school networks. The double advantage of this is seen as:

> Sharing the work of materials preparation – not the same thing as lesson preparation, though – and then being able to print off screens so that pupils can do reinforcement work on their own if they need to do so. (Mathematics teacher)

The growth of shared evaluation as well as shared material is leading to an enhancement of teaching and learning in a way that would not develop naturally within schools.

> We are developing flipcharts for the more and least able and building in animation of material. We then use the same materials for parallel forms, with one of the pair having static and one animated resources. We shall then evaluate attainment . . . to see whether there is a difference in retention because of IAW use. (Mathematics teacher).

Technology

The nature of IAW techniques used within the lesson
In both subject areas, the four most common techniques of securing interactivity were:

- drag-and-drop: matching a response to a stimulant
- hide-and-reveal: opening a response when a stimulant is understood, often used in a step-by-step feature or when using software with an immediate response (though this might be mediated by the teacher)
- matching: for example, equivalent terms such as fractions in mathematics, vocabulary in languages
- using movement: to demonstrate principles, for instance, angles on a line, sentence construction.

We found it quite surprising how this relatively limited and simple repertoire of techniques could be used in both subjects to produce highly engaging lessons where pupils appeared to be learning mathematical concepts and components of a modern foreign language.

Both subject areas made considerable use of the IAWs' colouring and shading facilities, for example, fractions in mathematics, parts of speech in language teaching and to mark sectors of a diagram or equivalent areas, or to mark parts of a sentence as construction developed. Colour is also used carefully in text and when teachers write on the IAW.

More of the mathematics lessons made use of commercially or professionally produced materials incorporating colour, shading and drag-and-drop with movement (for example, to demonstrate equivalence, the effect of adding and subtracting, and establishing rules for handling numerators and denominators), animation (for example, to show steps of an algorithm) and immediacy of response (for example, by marking an unlimited supply of decimal questions). By contrast, screens developed from the teacher's own work – often from Excel, Word or PowerPoint programs – did not appear to be as effective.

In *enhanced interactivity*, there was a tendency to use activities that featured several techniques and to employ a combination of commercially produced materials and those developed by the teacher. These lessons had greater pace and tended to use the IAW as the focus of all activity in both IAW-based exercises and extension work.

In one mathematics example, a Year 8 group developed algebraic equations through a starter based on coloured rods. An extension showed sequences with superimposition as these were developed, colour was used to highlight equivalence, drag-and-drop was employed as equations were built up, and then hide-and-reveal was utilised for examples worked out from the board.

In a modern foreign languages example, a Year 9 German group followed a three-minute revision-type starter with three activities that built vocabulary through highlighting, drag-and-drop and hide-and-reveal. Pupils then tackled building phrases, through activities ranging from pair work, drawing on the matching of vocabulary, gender and translation, to sentence construction based on the use of associated sound (provided by the teacher). They also imported pictorial material and 'real' newspaper or magazine extracts, for comprehension work and the application of vocabulary.

The internet was mainly used to download the games and activities that underpinned the learning of number relationships, shapes and equivalences, or vocabulary and phrase development, or even to provide audio links to check pronunciations.

In modern foreign language teaching, teachers used, and commented on, colour highlighting and arrows to indicate movement and positioning for parts of speech and to indicate verb endings. There were also instances when different screens were composed and given interest through attaching sounds.

Three linguists and four mathematicians outlined the use of supportive materials from the internet or other sources. Three teachers referred to the need to help pupils understand the technology – for instance, the use of IAW pens and programs – so that they can become fluent in the interactivity required if whole-class participation is to be assured. This was shown at work in two mathematics lessons where teachers helped pupils cope with the vagaries of the IAW pen, and in two language lessons where pupils were helped to use the whiteboard tools for dragging and revealing.

Teachers commented that dependence on sequenced slides in some pre-prepared materials in PowerPoint and Excel, as well as in some of the commercial materials, could inhibit flexibility in revisiting ideas and in offering alternative explanations appropriate to 'whether they can learn verbally or not'. This was not seen to be a problem in the observed lessons, where technological fluency was shown in the accessing of screens.

Fluency
Older pupils expected the teacher to be fluent in use of the IAW and associated software and able to lead their learning in such a way that their consolidation would take place in their exercise books. Such technological fluency was apparent more in mathematics than in modern foreign languages, seemingly due to the greater time that the IAW had been used in this subject area. Mathematics teachers in our sample also appeared to have more access to a range of 'clever', commercially produced material. Modern foreign language teachers were very aware of the lack of suitable, ready-made material and were spending a lot of time creating what they needed themselves.

All staff reported on how long it took initially to prepare new resources for the IAW. While most reported that they would welcome appropriate software, they also commented that there was currently little available.

The ICT skills of the teacher
All of our *enhanced interactive* teachers had, at the very least, good ICT skills that had been improved, often considerably over time, through the use of the IAW. This meant that they could deal with 'everyday' technological hitches that might occur in lessons.

These teachers had also employed a variety of software to help create their own resources that would use the IAW software, often learning more as their desire to produce another resource 'forced' them to discover new techniques – often in a haphazard way from colleagues or other teachers when discussing IAW resources. Only a few had attended any IAW courses of any significance (in terms of time).

Software
All the *enhanced interactive* teachers could use the software and resources provided with their IAW, but the implementation of the range of facilities within the software varied considerably. Although all the teachers could operate the features they wanted to use with few problems, most had not realised the full potential of the more complex aspects of the IAW software. In mathematics lessons, teachers reported a limited use of a wide variety of software, which included a spreadsheet, a geometry package, graph-plotting software and short programs. The teachers gave examples of commercial software written specifically for IAWs.

We would expect that, with more time, there will be greater use of subject-specific software as, even within this group, teachers were relatively inexperienced in using such software with pupils. Word processing, presentation software and the internet were all used in both subjects.

Alternative interactive presentation technologies
All the teachers in this study stated that they would not consider changing their IAW for an alternative interactive presentation technology.

Suggestions/recommendations

- For IAWs to have a significant impact on the teaching and learning of mathematics and modern foreign languages, teachers need to reach the *enhanced interactive* stage of development.
- To achieve this developmental stage most efficiently, priority should be given to developing appropriate CPD.
- A video for teacher familiarisation training should be commissioned so that effective training in IAWs can be made available to teachers either individually or in groups at times that suit their needs. In this way, familiarisation can be widespread and effective.
- Schools and departments purchasing IAWs should take the training needs of their staff into account, and provide sufficient resources to allow them to be trained.
- There are considerable advantages in moving forward a number of teachers in the same department together. A critical mass of teachers working together in one department, with the same make of IAW, is likely to make more significant progress than a number of teachers using different IAWs in a number of departments.
- At the time of purchasing an IAW, the buying of subject-related software specifically written for the IAW should also be considered wherever possible. However, care should be taken to ensure that the software supports enhanced interactivity. Having such software will help reduce the initial time taken by all staff in preparing their own resources.
- Consideration should also be given to the purchase of other appropriate subject software that might also support enhanced interactivity and be used effectively on the IAW. In mathematics, we would suggest a spreadsheet, a geometry package, graph-plotting software and short programs.

- Teachers will undoubtedly continue to produce their own resources, but staff should work together as a department, paying due regard to the storage and retrieval of individual and departmental resources.

- In preparing resources teachers should take into account the constraints of workload and the ability to work effectively and efficiently. They should endeavour to produce materials that enhance interactivity, primarily using the IAW as a means of prompting discussion, explaining processes, developing hypotheses or structures and then testing these by varied application.

- Making resources available to pupils out of lessons, through printouts of screens or allowing internet access, is still in its infancy, but may be an appropriate way forward.

- With regard to the purchase of IAWs, *The Good Guide to Interactive Whiteboards* by the Review Project (2004) should be consulted.

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