Developing Pedagogic Skills for the Use of the Interactive Whiteboard in Mathematics

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Most secondary schools offer some access to interactive whiteboards (IAWs) as teaching aids and it appears that Heads of Mathematics have been more ready than most subject leaders to embrace the technology. This paper will report on recent research at Keele University funded by the Nuffield Foundation, Becta and the TTA that has shown that teachers pass through a three stage developmental process. Initially the IAWs are used as a support for traditional, and often didactic, teaching but as teachers develop fluency in using the technology and pedagogic understanding they may progress to an enhanced interactive stage when not only the presentational benefits but also the pedagogic gains are understood and maximised.

To this end the team are investigating the ways in which interactivity can be integrated with lesson planning and delivery. To date they have identified three elements in effective mathematics teaching. These are systematisation and understanding of the techniques arising from IAW software use and development; the exploitation of the IAW as a source of support for verbal, visual and kinaesthetic learning styles, and the use of a variety of sources for materials. Further work has identified features associated with effective learning of concepts through IAW use and consequent cognitive development, and the identification of those elements that should be included in any form of teacher professional development.

Background

Evidence suggests that IAWs can have positive effects on teaching and learning (BECTA, 2005). The system linking computer, projector and board, offers considerable advantages in the presentation of learning materials the development of concepts and leads to enhanced motivation of pupils. Glover and Miller (2001, a, b, c, 2002, 2003) have reported on the use being made of the technology in both primary and secondary schools in England and have shown that it promotes pupil interest, more sustained concentration, and more effective learning where teachers are aware of the ways in which IAWs can be used to support a variety of learning styles. Teachers in both initial and continuing teacher training have been made aware of the technology and its potential for enhanced teaching effectiveness in a range of subjects and there has been specific work in assessing pedagogic use in some subject areas. Amongst these Miller et al (2003) and Edwards et al (2002) have summarised the impact on mathematics teaching in a number of secondary schools. The research to date has, however, concentrated on the benefits accruing from the technology rather than on analysis of the way in which teaching competence may need to be changed. This paper reports on an investigation of this issue through consideration of the way in which the IAW is being effectively used.

Methodology

From 2002 - 2004 members of a research team at Keele University worked alongside staff in 12 secondary schools in mathematics departments within the teacher training partnership and observed a further 12 mathematics teachers in schools throughout England identified as making particularly successful use of IAWs. In 2005 they have started working with a number of teachers in the early stages of IAW use as part of a study to ascertain typical entry level proficiency and both the process by which they attain fluency in the use of the technology, and the development of a changed pedagogy. The investigations are concerned with the observation of practice and use of the IAW and to evaluate the impact of the technology on pupil learning. It was considered that this would offer some indication of appropriate development training for teachers working with the technology. To this end arrangements were made to video-record a total of seventy one lessons of mathematics teachers using IAWs as the focus of classroom activity. Thirty six of the observations were of teachers working as comparative newcomers to IAW technology. Thirty five were with teachers who had had at least one year of IAW availability in their classrooms and these teachers were interviewed using a structured format and they also took part in termly group discussions at which further materials were developed for classroom use.

The video-recorded lessons were analysed with four main objectives:

a. To determine the use of the IAW within the overall lesson structure
b. To identify the techniques used in both teaching
c. To consider how learning was enhanced, and
d. To determine the development of concepts within the lesson framework.

To this end observations were made as follows:

- The timeline and activity sequence in each lesson. For Mathematics, with an established strong link to promoting cognitive development, the usual sequence was one of a starter, followed by exposition and development of the theme for the lesson, and then a short plenary session to ascertain the nature of learning to date.
- Classroom management issues. These included the way in which the room was set out for the lesson, the nature of the environment to favour or inhibit IAW use for all pupils in the room, the integration of the IAW with traditional textbooks and other resources and the use of pupil

groupings for learning activities. This observation also included evidence of the technological fluency of teachers in the preparation of materials and the use of the IAW, and looked for pupil fluency in working with the equipment including coping with the technology.

- Enhancement from IAW use. This was sought within a framework of revision of past work, establishing new principles and data, sequencing of information and appealing to different learning preferences, demonstration of processes and reinforcement of learning through recall and the use of examples.
- The contribution of IAW use to cognitive development. This was assessed through the establishment of aims, the use of varied learning styles, stepped learning sequences with revision as needed, problem solving, and recall and discussion as a bridge to further learning.
- The contribution of IAW use to the conceptual development of discrete elements in the lesson. This was determined through identification of processes, manipulation of data, review to ensure understanding and application as part of cognitive development.
- The nature of IAW techniques used within the lesson and the way in which pupils perceive these.
- An assessment of the teaching style prompted in the lesson.

Overall findings

The lessons were classified according to a typology evolved during the first phase of this work (Glover et al, 2005). This proposed that teachers passed through three pedagogic phases as they became more fluent with techniques and gained understanding of the nature of interactivity. These were:-

Supported didactic. This approach was characterised by the teacher making some use of the IAW but only as a visual support to the lesson and not as an integral strategy for conceptual development. The effect is that pupils see the use of the IAW as a novelty in the lesson but in pedagogic terms it illustrates, rather then develops concepts. An example of this was seen where the teacher used the fraction wall to demonstrate equivalence but did not then use any techniques to bring about interactivity. In another lesson a novice user illustrated the need to maintain balance in equations by drawing a see-saw on the IAW, showing an equation in balance and then proceeding to talk about changes to the balance, but without any movement on the see-saw – a tool readily available from the basic toolkit of movement within the IAW. In this situation the teacher was the focus, following 'traditional' approaches but did not use features of the IAW or pupil input, except in response to questioning or when following normal written tasks. However, teachers often start to use their own

materials ‘traditionally’ through PowerPoint, Excel or commercially produced programs. A further example was seen when a teacher, after using the IAW to present questions, carried out calculations on an adjacent non-interactive board. These were consequently erased and then referred to at the end of the lesson. A simple use of ‘pages’ to which reference can be made later would have been preferable. Of the lessons under review thirty two could be considered of this type, including two from the experienced users.

Interactive. – This approach marks progression from the supported didactic stage because the IAW is used to incorporate elements of the lesson that challenge pupils to think by using a variety of verbal, visual and aesthetic stimuli. There is a tendency to explore further the potential of PowerPoint, Excel and the software tools that come with the IAW. The IAW becomes the focal point of pupil attention usually to illustrate, develop and test discrete concepts. With this approach there are times when the teacher makes use of conventional approaches to ensure cognitive development and there is evidence of occasional lack of confidence in the technology or its teaching power. The IAW is no longer a novelty to the pupils, and is integrated into teaching and learning but its full potential is not developed. This was seen in one lesson where the teacher used a program on vectors downloaded from the Internet but then used an adjoining normal whiteboard to develop the processes involved. In another lesson a novice user had undertaken some additional training and was making use of an imported grid to demonstrate transformations. Typically at this stage teachers are advancing technical rather than interactive, skills often producing sophisticated but static presentations. Seventeen lessons were of this nature, including twelve taught by experienced users and five by the novice group.

Enhanced interactive. This is a progression from the previous stage marked by a change of thinking of the teacher who seeks to use the technology as an integral part of most lessons and who looks to integrate concept and cognitive development in a way that exploits the interactive capacity of the technology. As a result teachers are aware of the techniques that are available, are fluent in their use, and structure the lesson so that there is considerable opportunity for pupils to respond to IAW stimuli either as individuals, pairs or groups, with enhanced active learning. The IAW is used as a means to prompt discussion, explore alternatives, explain processes, develop hypotheses or structures and then test these by varied application. In one lesson this was demonstrated by the use of movement, colouring, shading and overwriting in teaching about angles on a line and at a point. In another lesson average speeds were being calculated but interest was stimulated by an imported visual clip, and then ‘virtual manipulatives’ (on-screen objects that can be manipulated that can be used as an aid to

understanding) were used to show average speed at the winning post. An experienced teacher who had been using an IAW for a year conducted such a lesson, almost entirely, from the back of the classroom. After some initial discussion and demonstration of three-dimensional axes and how lines and planes might intersect she encouraged pupils to go to the board to demonstrate solutions to increasingly complex questions. With the use of effective questioning, using drag and drop, hide and reveal and with effective use of colour pupils were able to develop and use standard procedures to calculate unknown lengths and angles. This stage teachers show enhanced understanding of the learning process, they talk about the ways that technology can support learning, and show ingenuity in developing materials to meet specific learning needs including differentiation of task for pupils, often focused on the IAW. Such teachers are aware of the contribution made by the IAW to different types of learning and seek to use this in two ways – through pupil movement in active learning with much increased use of pair and group work, and through movement of data on the board in a similarly active way so that the verbal and visual is linked to spatial changes that impact on the pupil. This stage is also marked by considerable teacher-pupil interchange. Twenty two lessons were considered to be enhanced interactive, all from the experienced user group.

It is recognised that there is a degree of subjectivity in such an analysis. With another group of pupils, or indeed, with the same group on another day it is possible that some of the more didactic lessons could have been interactive. Similarly, some topics lend themselves to an interactive approach whilst for others it may appear that they require conventional exposition. Four of the twenty four experienced IAW users involved commented that their planning varied according to topic and that they would not use the IAW unless they were sure of the learning gains. The classification of lessons could be differently applied by other observers but there was agreement between the research team of the criteria that justified classification in a particular group (and all the video evidence was viewed by one person). All the experienced users were enthusiastic about the technology and argued that the nature of their teaching had changed since the introduction of IAW technology. All of the novice group also considered that the IAW would impact on their teaching style. Of the twenty four experienced IAW users interviewed, three had some reservations about the way in which the IAW was prompting them into a certain ‘whizz-kid’ form of teaching, but all the others were enthusiastic to the point of suggesting that major changes had occurred in their classrooms as a result of their understanding and use of both technology and pedagogy.

Systematisation and understanding of techniques or 'manipulations'

The overall findings suggest that teachers develop facility in the use of IAW technology over a period of time. Interview evidence showed that this was most likely to be a rapid process where there was a coach or mentor within the subject department , particularly if he or she was a 'missioner' convinced of the value of the approach (Glover and Miller, 2003).

The techniques, classified as 'manipulations' (ways that one might use features of the IAW), used were as shown in the following table:

- ***drag and drop***, matching a response to a stimulant and used for classification, sequencing, grouping, matching, processing of data, the creation of questions arising from the dragging and the organisation of material - observed in, for example, drag and drop a fraction onto its correct position on a number line; drag a line into place to help read data from a graph; drag four decimals into the correct numerical order; drag the equation of a line to the correct graph
- ***hide and reveal***, opening a hidden response when the stimulant was understood, and also enabling material to be revealed as conceptual development takes place, stepping the development of hypotheses, and changing sequencing – observed in, for example, revealed answers after addition questions, revealing the answer to an addition of fractions after discussion of methods; revealing the position of a quadratic graph after pupils have plotted the points on a grid; and revealing the shape after pupils have been given information about it and have established its shape
- ***colour, shading and highlighting*** used for the collection of like terms, enhanced explanation, analysis through annotation and reinforcement through greater emphasis – observed in, for example, handling complex fractions from the fraction wall; using colour to help pupils to distinguish between different variables in an equation; using colour to help pupils with work on multiplying a number with a bracket; and using colour to distinguish between positive and negative numbers
- ***matching***, often using software to match items in some way, observed in, for example, matching equivalent fractions; matching a decimal with a fraction and a percentage; matching a statement with the probability associated with it
- ***movement or animation***, to demonstrate principles and to illustrate explanations – observed typically in stepped solutions that are animated by software, for example, an animation of how

to make a tangram; an animation of how to add decimals; an animation showing that angles on a straight line add up to 180 degrees

- ***immediate feedback***, from teacher, pupil or software often arising from direct consequence of one of the other five methods

In addition to these manipulations all teachers at all stages would write on the IAW. This could involve using the IAW in the same way one would write on a normal whiteboard, but could also include writing over other objects, for example, to illustrate particular points (and here colour might be used systematically). All users would do this and some novice users started just by using one or two colours of pen and use the IAW as they would a normal whiteboard, except that they saved the work for the next day.

The interview evidence suggests that teachers are prepared to use these techniques as they develop fluency and confidence. There is an apparent progression from 'toolkit' functions associated with the IAW system (software that allows users to do particular things on their IAW that varies widely according to the make of the IAW), to use of IAW programmes such as those offered by the Department for Education and Skills (the Interactive Teaching programs), commercial publishers such as Nelson Thornes (EXP Maths) and subject associations (Interactive Mathematics by the Association of Teachers of Mathematics). Teachers then become

> *'attracted by the ideas that the commercial material offers and so I attempted to build functions into my own work so that I could feel a greater sense f ownership with work that was really appropriate for my groups'*

But it is not simply a matter of content. We found that teachers also need to develop a fluency in recalling previous screens used in the development of a topic, or where work is being differentiated in recalling screens used for other age or ability groups. Revision use of prepared screens appears to be

> *'the thing that I liked best – the work was prepared and could be recalled but then you overwrite in whatever way suits you own need at the time'*

It appears that teachers are more ready to consider the ways in which the techniques can be effectively used – and this leads them naturally to question the nature of interactivity.

Early studies on IAW use have pointed to the need to develop a pedagogy that exploits this interactivity if they are to be other than a passing interest enhancing element in the classroom. McCormick and Scrimshaw (2001) investigating effectiveness of their use 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. This link between pedagogy and practice explored by Caine and Caine (1997) and Smith (1996) has led to further exploration of how interactivity can assist learning. Latane (2002) has demonstrated that interactivity with all technologies needs to be pupil-pupil as well as pupil-teacher based. Glover and Miller (2002) basing their work on Gardner's concept of multiple intelligences (1991) have indicated the need for immediacy of response and the opportunity to explore ideas as an adjunct to varied and enhanced presentation of material, and Iding (2000) working in initial teacher education for scientists has shown the need for the co-ordination of pictorial, textual and audio materials in fulfilling teaching aims.

For the teachers at our first stage, the supported didactic, the IAW is used in the same way as an ordinary board and although there may be some brighter presentation there is very limited use of the techniques that can present ideas in different ways. For those who are making a journey towards the next stage, interactive, understanding the technology and pedagogy is seen as an aid to traditional teaching rather than as the driving force for conceptual understanding and cognitive development. For many at both these stages, even the concept of interactivity is only understood as question and response and the potential for effective learning is consequently reduced. By contrast those teachers working at the enhanced interactivity stage use techniques to:

> '*offer the same idea in different ways until you feel sure that all the group understand and this requires meticulous planning and the need for continuous assessment so that whether answering at the IAW or on their own whiteboards, whether using individual or small group work, and whether working on examples or investigation, pupils are challenged not only to say what but also why'*

The teachers working with the research group recognised that interactive lessons may be an objective but that this required careful planning of sequentiality in lesson planning and concept development. The apparent advantage of using the IAW appeared to be that it was possible to show the same concept in

differing ways. There was however, little attempt to explore sequentiality and understanding of the ways in which IAW technology could foster learning processes.

Exploitation of potential for interactivity

All the lessons of those at the enhanced interactive stage were planned and taught with three underlying principles:

- the technology was used to support a lesson structure based upon an introduction or starter, a developmental phase based upon a sequence of learning incidents, and a plenary to review learning and contribute to metacognitive learning of the subject.
- most teachers were undertaking lesson planning that had a sequence of discernible cognitive aims and a series of activities to explore, develop, explain and reinforce both developing concepts and subsequent understanding
- there was a high level of teacher recognition that pupils learn in different ways and the IAW was used to promote diversity of aesthetic, verbal, numeric and kinaesthetic experiences

To support this work teachers identified and then explored the need to maximise interactivity between themselves, the pupils and the learning materials. They made full use of 'manipulations' (ways that one might use features of the IAW) and 'virtual manipulatives' (on-screen objects that might be used as an aid to understanding) on the IAW in the following ways:

- by creating, or finding, materials that provide opportunity to use 'manipulation' and 'virtual manipulatives' so that concepts can be illustrated and worked upon by the pupils
- by planning to share and evaluate materials with colleagues, with the intention of enhancing teaching and learning amongst people in a way that would not otherwise grow naturally within the school
- by use of the IAW as the focus of the lesson with pupils working with their own whiteboards, and coming up to the IAW to produce answers, to illustrate concepts and to explain processes
- by the use of immediacy of feedback either through programmed software or through the use of presentational tools
- by the use of materials in a way that can be differentiated on the same board although not perceived to be obviously so by the pupils by a range of staged examples

In short, the technology and pedagogy are fully integrated but there is need for teachers to draw from a range of resources.

Sources of materials

Teachers in the early stages of developing IAW facility comment on the time taken to prepare lessons to meet the multiple requirements of interactive and differentiated learning. Initially they appear to make use of some aspects of IAW software, PowerPoint presentations developed to illustrate concepts and provide examples but mathematics teachers also have access to a variety of software programmes that can be used such as generic 'content-free' software (typically spreadsheets, geometry and graphing software); IAW specific software (typically Interactive Teaching Programs, EXP maths and Interactive Mathematics) and files for use with the IAW software that are supplied by the IAW manufacturers.

As they become more skilled teachers also make use of basic techniques of using the IAW software e.g. in moving shapes around grids, or in demonstrating geometrical concepts with ruler, and protractor. There is an increasing amount of material for download from the internet but except for sites like the National Whiteboard Network (part of the part of the Primary National Strategy) you cannot guarantee the quality of any of the materials until you have used them.

The development of interactivity may be extended from the focus on the IAW and even at the earliest stages of use there was evidence that teachers attempt to integrate some other ICT resources such as Excel spreadsheets, and its ability to perform calculations or graph data, and support immediate feedback for examples being worked through on the IAW. This was evident in seven of the lessons reviewed.

Interview evidence showed that teachers are also working through their own practice regarding the use of non-ICT materials including textbooks, and associated exercises. It appears that teachers in the early stage of IAW use rely heavily on these and

> *'go through some sort of soul searching about whether we should or should not be going along traditional lines. My argument is that if I am taking time preparing materials for IAW use, I ought to be able to build in some sort of assessment so that I can save time in that direction'*

In twelve of the lessons teachers were following this precept by using 'quick check' of calculations written on pupil non-interactive slates, and two were using associated tablets for pupil answers as the lesson progressed. It would appear that, as teachers achieve fluency in the use of the technology and deeper understanding of stepped pedagogy that they are more ready to embrace further technology to enable them to support learning.

We noticed that teachers were increasingly using materials that are held as files on a departmental base and there was evidence that schools are planning lessons in such a way that to maximise use of common resources. Individual teachers spoke of the filing systems that enabled them easy recall of materials and the need for classification systems, for example, by topic and stage to make this feasible.

Achieving interactivity – the basis of teacher development

If teachers have moved to the enhanced interactive stage it is unlikely that there could be a reversion to conventional IAW approaches because they acknowledged in interviews that both teaching and learning have gained from an integrated approach that brings together technology, knowledge of the ways in which people learn, and of pedagogic approaches that cater for those needs. Further consideration of the way in which teachers worked in the twenty lessons classified as showing enhanced interactivity offers pointers to future professional development work. Good practice involved the following characteristics.

a. Lesson structure

- Pre-planning and preparation. There was a general view (evident in sixteen of the lessons) amongst those interviewed that 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.

- Lesson structure. The need for tight lesson preparation meant that effective teachers maintained a structure that offered strength because it had inherent progression for conceptual development and offered opportunities for cognitive growth through reflection. This was true of eighteen of the highly rated lessons. The technology was usually being used to support a lesson structure based upon an introduction or starter, a developmental phase based upon a sequence of learning incidents, and a plenary to review learning and contribute to metacognitive learning of the subject. Awareness of the three elements (starter, development or main activity, and plenary or review) appeared to give teachers a framework for lesson preparation and those lessons where this was not so often fell foul of the clock! In the plenary or review eighteen of the twenty one teachers also drew attention to the clear match of objectives to activities and the need for pupils to use the IAW to help in their evaluation of progress.

- Planning for concept development. 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 the confidence in a logical and well-presented teaching and learning sequence. This was evident in twenty lessons. Teachers were then able to depart from the prepared 'script' and use fresh or recalled screens to explain or discuss issues arising. Furthermore, the pace that was generated by such planning left less time for behaviour issues to emerge, with pupils apparently on-task for a significant proportion of the lesson.

- Planning for differentiation. The strategy of pre-planning also allowed teachers to plan for activities that would involve all pupils. In seventeen of the observed lessons the teacher was free to circulate, to help individuals where necessary and to intervene to prevent possible escalation of behavioural problems. Differentiation was achieved in eighteen of the observed lessons through graded examples, extension material and 'challenges' to groups working at the IAW or on laptop computers. 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 '*aware of the ways in which consolidation can occur without going back to old fashioned practices such as copying'*.

b. Classroom management

Interview and observation evidence points to a number of issues in classroom management. This was defined as the management of aspects of the learning environment and pupil teacher, pupil-pupil interaction in the classroom.

- Learning management. 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 whilst their focus was on board based material. Recalling material by the use of previous screens meant that issues arising from the teaching material or topic could be dealt with, thus giving pupils' queries more time and attention, and would seem to indicate to pupils that their appropriate contributions and queries were valued. Enhanced interactivity had this element of flexibility that capitalised on such queries. The print-off facility meant that deviations from the script could then be recorded and retained with the material for revision purposes or for pupils absent from a particular lesson. However, for a number of reasons, some managerial, the facility to print off resources, was under-used and evident in only four of the twenty two observed lessons.
- Marking and assessment. There was considerable evidence that assessment procedures were developed alongside the lesson plans themselves and as such evolved in step with lesson plans, again to meet changing need and context. In one lesson marking time was minimised thus; a series of screens was used for checking homework, allowing students to self-mark quickly as a group, while the teacher circulated. In eighteen of these lessons there were at least three assessment points.
- Storing and editing lessons. Using an IAW all the time means that teachers eventually had to think about how to store lessons in order that they could find them again. This tended to be overlooked early on, so lessons were stored with inappropriate names and non-systematically. Generally once teachers had 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 being used in a different context

It was evident that teachers saw the benefits of saving as the basis of future lesson planning. This meant that basic lessons could be refined from class-to-class or year-to-year, in the light of changing pupil need and context. Teachers had material stored in such a way so as to be able to access it quickly within a lesson, responding to the needs of the class at that moment as was shown in nineteen of the observed lessons. Teachers recognised that often changes needed to be made to materials, but still saw this retention of previous work as a major benefit.

Pedagogic factors

Teachers were aware of the particular demands arising from the introduction of IAW technology. One commented that

'You have to be much more aware of the way in which you can use the IAW to promote a different way of learning – or at least offer alternatives that youngsters can gain from'

These included:

- Awareness of preferred learning styles. In our sample there was a high level of teacher recognition that pupils learn in different ways. All lessons showing enhanced interactivity drew upon a range of styles by offering different approaches to topics during the lesson. Further, three practitioners were particularly skilful in working with the less able using the IAW.
- Clear visual representation of concepts. Teachers commented on the particular advantages for some pupils who needed reinforcement through the presentation of data or processes with more than one learning style. This was shown in fifteen lessons where pupils appeared to gain from the visualisation of structures in contrast to more verbally dominated approaches alone (the fraction wall, coloured rods as algebraic objects).
- 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.
- Activities that encourage an active, thinking approach. In all the observed lessons it was clear that teachers were using learning of concepts as a basis for cognitive understanding. As a result there were discernible cognitive aims and a series of activities to explore, develop, explain and reinforce subsequent understanding.
- Progression. In eighteen of the observed lessons, there was a continuing upward progression in learning and attainment. In one lesson the teacher commenced with the aims of the lesson on the IAW, used these as the pegs upon which activities were to be developed and then used different methods of assessment 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*'.
- The importance of sequencing. In eighteen lessons learners were encouraged by easy identification of key concepts, and preferred being clearly led to understand complex concepts rather than having material '*dumbed-down'*.

- Immediate feedback. These programs were most effective as starters or for work with the least able when rapid responses and moving on enhanced both number and word manipulation. However, in sixteen of the observed lessons with more able pupils teachers prompted worthwhile discussion and explanation at some stage in the lesson by getting pupils to explain, illustrate and direct from the IAW and thus to have to verbalise what they had been learning. Because manipulations were available, where pupils can move items on the IAW, this was regarded as being easier to do, and far more effective than with other presentational means (e.g. using a screen compass and protractor in a geometry lesson).
- Recall to strengthen learning. In twenty of the lessons showing enhanced interactivity teachers emphasised the impact of recall from lesson to lesson as a means of sustaining pupil understanding and achievement. In these lessons there was evidence of recall at the start of the lesson, at an intermediate stage and during the plenary session – and the IAW remained the focus throughout.

Conclusions

Teachers need time to develop their technological fluency, apply pedagogic principles to the available materials or to the development of materials, and then to incorporate the IAW seamlessly into their teaching. Few teachers base all their lessons on the IAW all the time, and over half those interviewed stressed that the IAW has to be seen as part of the equipment available but that there was still a need for the use of texts, exercises and other media. Teachers then appear to become more aware of the nature of interactivity and its stimulation as the basis for conceptual development and cognitive understanding. Pupils also need to have a range of manipulative skills if they are to take part in lessons without loss of self-esteem as technologically incompetent. Even so good practitioners ensure that all pupils have access to the board, and are given help if there are signs of unhappiness with the medium.

It is only when basic technological fluency and pedagogic understanding has been achieved that teachers can then overcome the novelty factor. This is not to suggest that the IAW is a panacea for all ills. Our evidence suggests that there is a teacher progression from supported didactic to enhanced interactivity in their classroom and pedagogic management and that this progress is neither continuous nor consistent depending upon the groups being taught and the lesson material, nor is it evident that all teachers will progress to the enhanced interactive stage. Where there is still reliance on copying of material, textbook exercises and minimal conceptualisation of learning, the gains are minimised.

Effective learning is inhibited where the IAW is given a novelty value by the teacher so that it becomes something different, where the physical surroundings are not conducive to IAW use and where the lesson lacks pace. It is not sufficient to argue that the use of the IAW will, of itself, bring the classroom into the 21st. century and continue to provide a visually stimulated environment. Effective teaching requires that the technology and the pedagogy are directed towards enhanced and structured understanding. '*I love my board because it gives so much to the kids*' may be the clue that enthusiasm can be regenerated not just in the pupils but in the staff also.

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