MOTIVATION: THE CONTRIBUTION OF INTERACTIVE WHITEBOARDS TO TEACHING AND LEARNING IN MATHEMATICS

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A research team from Keele University has worked with 12 mathematics departments in partner school to evaluate the motivational effects of using interactive whiteboards in mathematics classrooms. Although at times it is not easy to separate presentational and motivational effects a number of factors are considered by teachers and pupils to impact upon pupil motivation. Interest and enjoyment were most evident in lessons where the interactive whiteboard, not the teacher, was the focus of the lesson. However, the interactive whiteboard in itself is not sufficient to ensure that pupils are motivated, it is instead the pedagogical stance and the quality of the teaching that enhance motivation.

BACKGROUND

Between April 2002 and March 2004 members of the Keele University Department of Education Interactive Whiteboard (IAW) group took part in research funded by the Nuffield Foundation to ascertain the rationale, practicalities, pedagogic implications and outcomes of the use of interactive whiteboards in secondary school mathematics departments within the Keele University Partnership of initial teacher education schools. From September 2003 to March 2004 the same research team were involved in British Educational Communications and Technology Agency (Becta) funded research looking into 'best practice' in mathematics and modern foreign language teaching using IAWs.

There has been considerable research into the way in which pupils are attracted by teaching or learning involving the IAW. Carr (1999) considers whole class use of the IAW whilst Blane (2003) deals with motivation in the primary classroom; Clemens et al (2001) describes the gains from the IAW when used in learning enhancement for slower learners, and Bell (2000) and Blanton and Helms-Breazeale (2000) describe attempts to enhance motivation through the use of technology to help those with special needs and literacy learning problems. Miller et al. (2003) report on the perception of teachers in training on the impact of using an IAW on pupil motivation.

Miller et al. (2004) suggest that there is a developmental process where teachers might progress, or not, through three stages: 'supported didactic' where the teacher makes some use of the IAW but only as a visual support to the lesson and not as integral to conceptual development; 'interactive' where the teacher makes some use of the potential of the IAW to stimulate pupil responses from time to time in the lesson and to demonstrate some concepts; and 'enhanced interactive' which is characterised by the development of teaching and learning strategies to shift the focus from the teacher to the IAW and pupil centred learning.

METHODOLOGY

The Nuffield Foundation research involved 11 meetings with the 12 mathematics teachers working with the research team, classroom observation of teaching and semi-structured interviews with teachers as well as group interviews of pupils.

At the initial meetings, where most of the teachers were relatively inexperienced IAW users, time was set aside for the teachers to consider the gains that might be made from IAW use, and this led to the development of a structure for the observation of lessons. So that the lessons might be analysed in more detail it was agreed that they would be video-recorded, and the teachers agreed to taking responsibility for ensuring that appropriate permissions were granted. The research team, following consultation with the group of teachers, drew up the semi-structured interview schedule; this was piloted, adapted and then used for the teacher interviews. At five of the later meetings time was set aside to discuss the summaries of classroom observation and interview evidence in order that it might allow for a 'grounded' analysis.

This research team built the Becta research on the early Nuffield Foundation work and used the same classroom observation and semi-structured interview schedules. The teachers included in this part of the research were 'identified' as likely to be working at a 'best practice' level.

This paper is concerned with 30 mathematics lessons that were observed and video-recorded. The majority of the lessons lasted for between 45 minutes and one hour and all were a single age group of pupils with pupil ages varying from 11-12 year olds to 15-16 year olds. Most observations were made of a variety of groups classified by ability in terms of 'upper', 'middle' or 'lower'. Virtually all groups had 20 - 30 pupils in the class and included both males and females.

In total 22 mathematics specialist teachers were interviewed, though not all were video-recorded. The interviews looked to probe, amongst other things, the perceived motivational aspects of the IAW and how it made a difference to pupil engagement and learning. Two groups of ten pupils each were interviewed in two schools to gain some triangulation with teacher opinion.

The video-recorded lessons were analysed according to a set format with observation of: the timeline and activity sequence in each lesson; classroom management issues; the nature of IAW techniques used within the lesson and their perception by pupils; an assessment of the teaching style used in the lesson; teacher and pupil technological fluency; identification of practical and pedagogic issues; enhancement resulting from IAW use within a framework of pedagogic elements; the extent of 'on task' work when the IAW was the focus of attention and when it was not, judged by observation of a single pupil; the percentage of the lesson when the IAW was the focus of teaching and learning; the contribution IAW use made to conceptual development; and the contribution IAW use made to cognitive development.

At the conclusion of each observation the lessons and the teachers were classified according to the teaching style observed in that lesson, using the categories of ‘supported didactic’, ‘interactive’ and ‘enhanced interactive’. This gave a measure of the extent to which the teacher had incorporated pedagogic change into the lessons through enhanced activity.

FINDINGS

In the report that follows the analysis necessarily addresses subject specific issues but we believe that many of our observations and comments may well be generic and these could prompt further understanding of gains from IAW use.

Of the 30 lessons observed 8 of them were classified as having a supported didactic teaching approach, 10 an interactive approach and 12 an enhanced interactive approach. This suggests that in just under three quarters of the lessons (22 out of 30) the teachers demonstrated fluency in the use of IAW techniques and had access to a range of techniques and material that allowed them to work at the interactive or enhanced interactive stage. This was not completely unexpected since many of the observations were made of teachers ‘identified’ as likely to be working at a ‘best practice’ level. A small number of teachers worked at two different levels in different lessons and this appeared to be determined by the materials available as much as by the way in which they were used. This appears to show that these teachers had not fully engaged with working at either the interactive or enhanced interactive stage.

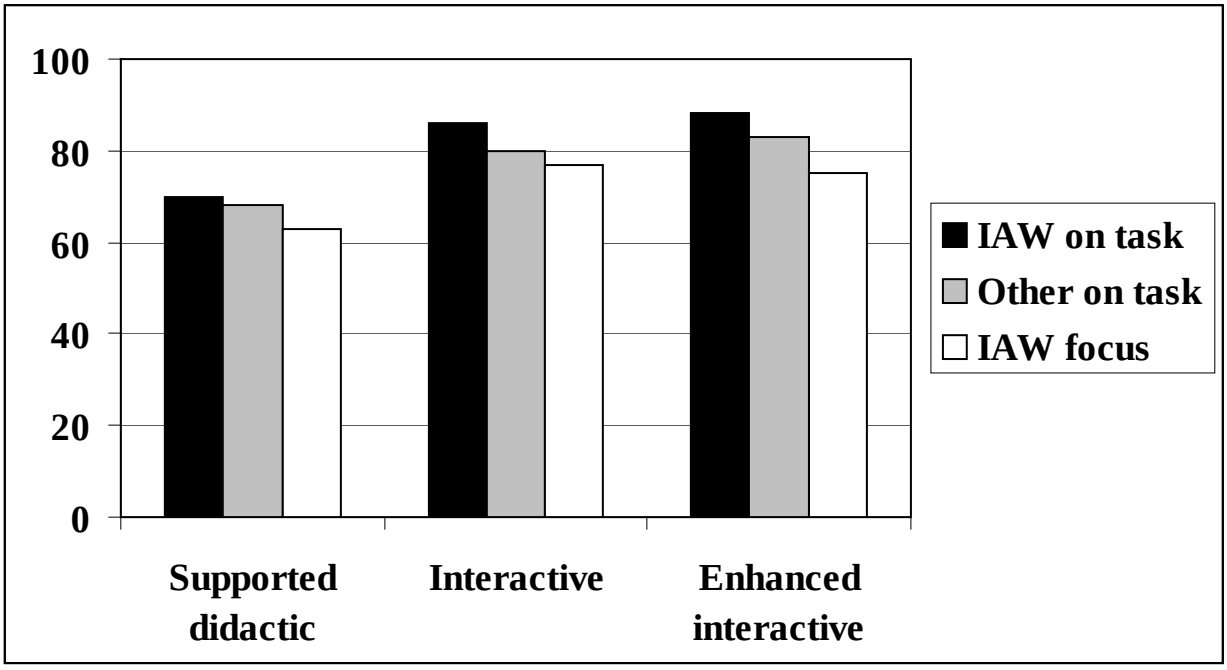

Figure one: The relationship between teaching approach and IAW use

The observed lessons all showed that the teacher was not the focus of the lesson in the way that they might previously have been. Figure one shows both pupil ‘on task’ time as a percentage of the time that the IAW was in use, a similar percentage for when the IAW was not in use, and the percentage of the lesson when the IAW was in

use. These are all shown plotted against the type of teaching approach observed. There is a subjective element in these observations because not all 'targeted' pupils were visible for the whole lesson. The proportion of the lesson where the IAW was the focus is generally a more reliable indicator but even so activities sometimes continued whilst pupils were working in pairs or with exercise books.

We believe that the impact of enhanced motivation can be seen in the attitudes to learning as shown in Figure one, with the highest time for 'on task' activity, whether the IAW was in use or not, in the observed lessons where the teacher was working at the enhanced interactive stage and the lowest times when the teacher was working at the supported didactic stage. In those lessons where the IAW was used 'only' as a support, categorised as 'supportive didactic', there were clear changes of pupil attention and attitude. In some of these lessons, when the teacher replaced the IAW as the focus of activity, pupils' interest waned and, at times, there were behavioural management issues that were not evident during the IAW based activity.

Initially there were concerns that there could be a novelty value associated with the use of the new technology and that any motivational gains might disappear with time, particularly if pupils had all lessons in all subjects with teachers using IAWs. But there were also worries about not using IAWs, expressed by one teacher who commented '*there is now danger that if we don't use the technology we will be seen as lacking in some way*'. To address these concerns teachers had developed strategies to ensure that there would be a continuing upward progression in learning and attainment. For example, in one mathematics lesson the teacher started 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'*.

This recognition that the IAW in itself was a motivating factor was moderated by the way in that the teachers intuitively recognised that the motivation of pupils stemmed from the way in which teachers exploited a '*different type of contact with the lesson in the pupils hands*'. Good practice obviously builds upon knowledge of particular groups and of individuals within the groups and a realistic assessment was that '*the IAW still doesn't mean that we shall have a lesson where all the pupils are paying attention all the time*'.

All the teachers were enthusiastic about the technology and argued that the nature of their teaching had changed since the introduction of IAW technology into their classrooms, suggesting that major changes had occurred in their classrooms. A number also commented that the IAW had been a motivating factor for them and had renewed their enthusiasm for teaching mathematics. However two of those interviewed had reservations about the way in which the IAW was prompting them into a certain form of teaching.

In discussion with participant teachers it was at times difficult to differentiate the motivational factors from the presentational or pedagogic in the successful use of the IAW. Broadly, the evidence showed that the perceived major features that encourage pupil motivation can be classified in three ways: first the ***intrinsic stimulation*** provided by the combination of the visual, kinaesthetic and auditory paths to learning; second the ***sustained focus*** maintained throughout the lesson by the teacher's management and 'orchestration' skills; and third ***stepped learning*** through constant challenges with frequent assessment of achievement as a stimulant to further involvement. The second and third of these three classifications are features of ***effective management*** that can be seen typically in IAW lessons where the teaching approach is classified as enhanced interactive.

Intrinsic stimulation

In all lessons observed, teachers were able to capitalise on the intrinsic stimulation offered by the IAW. The use of 'colour, highlighting and shading' was extensively used in work on fractions, angles and algebra to engage and enable pupils to see clearly what was being discussed, to describe parts of the diagrams in explanations and to clarify, for example, equal angles. Similarly, the dynamic features of the IAW, such as 'drag and drop', i.e. moving an on-screen object from one place to another, allowed the use of 'virtual manipulatives', significantly in work on geometrical construction (the virtual manipulatives of on-screen pair of compasses, ruler and protractor), and in demonstrating equivalence of fractions using the virtual manipulative of an on-screen fraction wall. Pupils were also motivated by the opportunities to use virtual manipulatives, seeing it as *'fun arising from the use of tools'*. Examples of these virtual manipulatives, taken from one commercial software package (EXP Maths 7, (2003) Miller and Sherran, Nelson Thornes) are shown in Figure two.

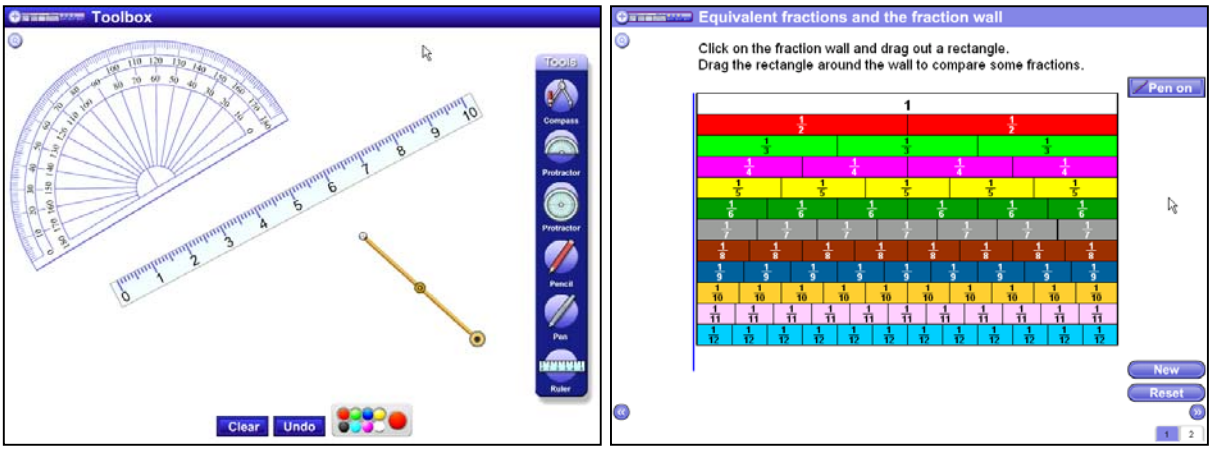

Figure two: virtual manipulatives - tools and a fraction wall

The use of 'hide and reveal', hiding an on-screen object so that it might be 'revealed' at an appropriate point, enabled teachers to promote conjecture and discussion before answers were shown.

Teachers in interview were clear that interaction based on these features made explanation easier and sustained pupil motivation. However the only auditory stimuli used in the lessons were the voices of the teachers and the pupils, however in the enhanced interactive lessons it was suggested that pupils' voices were heard more often than in non-IAW lessons.

Evidence from the pupil groups mirrored that of the teachers. When they were asked to identify why lessons were of greater interest than in traditional teaching they also identified the intrinsic stimulation of 'colour, highlighting and shading', 'drag and drop' and 'hide and reveal'.

It was clear that where lessons had dynamism and attraction they appeared to offer interest and challenge. Typically such lessons supported both revision of earlier work and enhanced understanding of new work. Teachers were conscious however of the time demands for preparation even when using commercial materials, and three referred to the problems of technology that could inhibit use of the IAW. In the observed lessons there were problems with the technology in 10% of the recorded lessons. When such demands hindered the progress of lessons the motivational advantages to pupils and staff were lost.

The impact of enhanced motivation can be seen in the attitudes to learning prompted by the IAW. One pupil commented of their teacher '*she has become a bit of an expert since she had the IAW*' but it was noticeable that in the same class the pupils had also gained, according to the teacher, and this was shown in neater exercise books, greater use of colour and presentational techniques and a higher standard of homework completion – the IAW appeared to offer a standard not previously seen with conventional boards.

One final contribution to motivation offered by the intrinsic stimulation of the IAW and highlighted by the research is the relative ease with which it is possible to show the same concept in different ways to ensure understanding and retention. Being able to represent and consider fractions in their many forms, such as on a fraction wall, as fractions of a whole and as a numerator over a denominator, means for the teacher that fewer pupils are likely to be excluded from the lesson. In this respect 20% of the teachers commented upon the particular advantages for slower learning pupils or those who need reinforcement through the presentation of data or processes using more than one learning style. One comment is significant in that it may have highlighted a particular feature of the slower learning group concerned. '*You have to remember that the lower groups are rather small – in this school averaging only 16 and often with a classroom assistant – and this allows a much greater level of pupil participation. As a result they achieve and feel wanted.*'

Effective management

The extent to which motivation is developed and maintained by what the IAW offers in terms of effective management opportunities is discussed under two headings: the

first, how the IAW is used as a sustained focus for the lesson and the second, how the board is central to stepped learning.

Sustained focus

When teachers used an enhanced interactive teaching style or, to a lesser extent, an interactive teaching style the focus of the lesson shifted from themselves to the IAW. This allowed them to sustain interest and engagement as discussion and activity were focused on the IAW. One teacher spoke of himself as: *'an orchestrator whilst the pupils explain, illustrate and direct from the IAW and this has changed the way in which I can involve them all in the lesson'*. The use of the IAW in this way was regarded as a key factor in enhancing motivation.

Effective teaching with the IAW appeared to motivate through the way in which it stimulated learning through participation and understanding. In so far as it affected motivation just under three quarters of the interviewed teachers commented upon aspects of involvement (i.e. the sustained focus of pupils), and 60% noted that the progression of the lesson fostered understanding and achievement as the basis of enhanced self-esteem. In some classrooms this was demonstrated by more movement by the teacher, and by pupils working in groups or at the IAW, than in conventional teaching. Such collaborative work appeared to increase participation and self-esteem, central to maintaining motivation. Pupils' responses supported this notion of sustained focus with responses typified by '*lessons had less wasted time*', and that '*they moved with more pace so that they didn't want them to come to an end*' a view supported by classroom observation evidence. Three teachers noted that the constant progression in an interactive situation maintained the pace of the lesson and as such absorbed those who might otherwise go 'off task' in a traditional classroom, with the result that the pupils were less 'nagged' by the teacher during the lesson, thereby increasing enjoyment and supporting motivation. Motivational influences thus appeared to become integrated with the pedagogic aims and teaching strategy of IAW use.

Stepped learning

Once the board was established as the focus of the lesson, the teacher was able to sustain pace and develop a teaching strategy by using *stepped learning*. This was a particular feature of effective lessons that were classified as enhanced interactive teaching style.

Perceptions of *stepped learning* were suggested by teachers in comments about the sequential development of ideas, constant challenges and constant feedback with exemplars resulting from pre-prepared and commercial software, such as EXP Maths 7 (Miller and Sherran, 2003, Nelson Thornes). They also mentioned that the opportunity to revisit earlier concepts and examples allowed them to underpin understanding. A particular motivational gain highlighted by teacher interview and lesson observation concerned the impact of visual recall from lesson to lesson (i.e. stepped learning across lessons), often stimulated through IAW specific software as a

means of sustaining pupil understanding and achievement. As one teacher commented: '*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 the Internet gateway'*.

Additionally teachers mentioned demonstration using 'movement and animation', in which the IAW's features were used to 'run through' or 'animate' routines (operating with fractions) or exemplify what was being discussed (the angle sum of a triangle).

If there is one single motivational factor for pupils during lessons that ensures maintained interest it appears to be the immediacy of response. Although not referred to by teachers, pupils consider the availability of games that support learning to be a key motivational factor. These were usually features of commercial software or Internet sites. Such games required responses that can be immediately assessed and then linked to a scoring system. Such competition, properly managed, between individuals and/or groups promoted engagement and the drive to succeed – a key stimulus in the cognitive interactionists' model of motivation (Bigge and Shermis, 1999).

Conclusion

Whilst it would be easy to claim great advantages for the IAW in motivating pupils at all ages it is evident that it is the pedagogical stance and the quality of the teaching that ensures progress.

In an assessment of two lessons, both using professionally developed fraction wall materials to enhance learning of fraction equivalence the less successful began with problems of vision of the screen, continued with three longer periods of activity during which pupils lost interest, and degenerated into a conversation between the teacher and those who were nearest to the board and most interested in the lesson. By contrast in the other lesson the teacher used groups of pupils to demonstrate equivalence, and then worked with the whole class to establish rules of process as a '*genuine voyage of discovery for them – they saw that they were doing the learning, I was merely opening the gate of understanding for them'*.

Perhaps one comment from a pupil sums up the motivational impact of the IAW. After a lesson in which the stages of equation solving were developed in three different ways, one girl said '*Oh, my God, it is so easy when you put it like that – and I won't forget again'*.

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