Interactive Whiteboards in educational practice: the research literature reviewed.

Ton Koenraad
Hogeschool Utrecht University of Applied Sciences
Faculty of Education

TELLConsult
www.tellconsult.eu

Ton.Koenraad @ gmail.com
Contents

1. Introduction ..................................................................................................................2
   1.1 Method.....................................................................................................................3
   1.2 Contents..................................................................................................................4

2. The added value of Interactive Whiteboards .........................................................5
   2.1 IWB versus computer-projector setup.................................................................5
   2.2 Pros and Cons of Interactive Whiteboards .......................................................6

3. Further analysis of some specific aspects .............................................................10
   3.1 Engagement and motivation...............................................................................10
   3.2 Interaction...............................................................................................................11
   3.3 Learning results ....................................................................................................12
   3.4 Learning styles, special education .....................................................................13
   3.5 IWB Materials.......................................................................................................14
   3.6 Training and professional development............................................................15

4. Conclusions ...............................................................................................................18

5. Literature..................................................................................................................21
1. Introduction

This study is one of the results of the working group initiated by the Faculty of Education of the Hogeschool Utrecht on the occasion of moving to a new building with technologically state-of-the-art equipment, including teaching spaces equipped with interactive whiteboards (IWBs). It aims to map implications for staff and curriculum and provide a specialized collection of literature references.

We present an overview of prominent research on this subject as available at the time of writing (January 2008). We summarize the main conclusions from the most relevant studies. Our main objective is to provide a resource for colleagues, affiliated school based teachers and also for teacher educators and trainers of partner organisations to support the development of their personal and our common knowledge base on this subject. In addition an extensive bibliography was developed as input for a domain & discipline-specific collection of resources to be used for the professional development of individual teacher educators and to support a variety of initial and in-service courses.

Furthermore it is hoped that access to research and debate about what 'good practice' with reference to IWB-use implies also contributes to the development of educators' personal skills and the quality of initial training in this respect. Because - though an IWB might not immediately remind one of computers – we are obviously dealing with the use of ICT in education. And, as is the case with all uses of ICT in training and professional activities, the impact the model behaviour teacher trainers (should) display may have, can be enhanced if trainers can make links to (subject-specific) pedagogy and manage to organise reflection on the educational use of this specific ICT product.

Finally, in providing this overview of the published literature on this subject in the period 2000-2007 we seek to offer support in finding more detailed information on specific aspects of the use of IWBs (in Dutch also referred to as 'digiborden') and to inspire further literature and action research on subject-specific applications.

1.1 Method

The amount of publications on the educational use of IWBs is steadily increasing. The 'wow' factor is typical for most of the publications that has accompanied the introduction of this technological innovation of the classroom in its early stages. A substantial part does not offer more than descriptions of the functionality of the boards and the software supplied with them in relation to their educational potential. Among them also quite a few personal anecdotes, a lot of opinions and sketches of personal practice. Whatever research is available is usually small scale and mostly based on practices in primary education (Smith et al., 2005).

Until recently, scientific research was quite rare (Collie, 2002:7; Cutrim Schmid, 2007:123; Glover et al., 2005; Smith et al., 2005). And also mostly in English as educational institutions in countries such as the UK, Canada, America and Australia were first to adopt this technology.

With the availability of several recent large-scale studies such as Higgins et al. (2007), Moss et al. (2007), Miller & Glover (2006), Schuck & Kearney (2007) and Somekh et al. (2007) this situation has recently improved. Among others these papers report evaluation research of the English Department for Education and Skills (DFES) policies on literacy and numeracy in primary education. This National Literacy Strategy (NLS) and Numeracy strategy (DfEE, 1998, 1999) aimed to stimulate the quality of whole-class teaching. It was expected that whole-class, interactive teaching, defined as ... “when pupils' contributions are encouraged, expected and extended” (DfEE, 1998a: 8), would contribute to this considerably. In this context, substantial grants have been made available1 to schools for the purchase of digital presentation equipment.

The central research question in the evaluation research studies is whether the underlying assumption that the technical interactivity of the board will also lead to more interactive teaching, or possibly transformation of education, can be validated.

1 In the period 2003 – 2005 the UK government provided 25 million Pounds worth of grant money for the purchase of IWBs.
In addition to the publications mentioned we have also included so-called meta-analyses by other authors and agencies such as some studies commissioned by the British Educational Communications and Technology Agency (BECTA), e.g. "What the Research Says About Interactive Whiteboards (BECTA - ICT Research, 2003).

Furthermore, a white paper entitled "Interactive Whiteboards and Learning: A Review of Classroom Case Studies and Research Literature (SMART Technologies Inc., Apr 2004), a Smart-funded research. And relevant parts from "The ICT Impact Report: A Review of Studies of ICT Impact on Schools in Europe ' (Balanskat et al., 2006), a study commissioned by the EU.

For more detailed scrutiny of some specific aspects, we also included review studies such as "How can the use of an interactive whiteboard enhance the nature of teaching and learning in secondary mathematics and modern foreign languages?" (BECTA, 2005) and some articles frequently referred to in the above meta-analyses.

Finally, to locate good practice, we have also screened more practice-oriented publications, lesson reports and repositories of materials, such as "Getting the Most from Your Interactive Whiteboard: A Guide for Secondary Schools (Becta, 2004) and the document 'Information Guide Digital School Boards' (Kennisnet / ICT in schools, Zadelhoff, 2007).

This literature review is therefore largely based on international publications with a strong focus on the situation in the United Kingdom. To add more detail and nuance to a number of our global and cryptically worded findings we have amply quoted from the original, predominantly English, papers.

1.2 Contents

In the present report, we respectively discuss the technical potential of IWBs, the impact of their use in education, and the results of empirical research on the effects on learning and student attainment. We first address questions one could ask when mapping the added value of digital presentation facilities. Then we summarize the results of research on specific issues and implications for teaching and learning processes. Whenever possible we refer to the main sources on which we base our conclusions with respect to various issues. For more detail (including domain and subject-specific research) a selection of literature references from other studies is available at: http://www.callinpractice.net/IWB/Research
2. The added value of Interactive Whiteboards

2.1 IWB versus a computer-projector setup

The discussion on the added value of IWBs among (Dutch) educationalists is dominated by two issues: one is about the principled question whether the board in fact mainly if not only supports teaching functions (explain, demonstrate, present, instruct) and with that stimulates whole-class, teacher-centered teaching (again?).

The other issue is whether a computer-projector setup might not serve equally well as it provides affordances similar to those of IWBs at less cost.

The first question is motivated by the concern that IWBs help to set the pedagogical clock back. As, indeed, at first sight the 'sage-on-the-stage' model seems difficult to reconcile with emerging views on challenging and effective education: independent learning, (co-)construction of knowledge (products), activating methodologies. In that context, in a number of countries at least, there is a trend to use ICT to support diversity, personalized learning and (tele) collaboration: made-to-measure tutorials and exercises, networks and—in affluent parts of the world—(almost) all students (?) their own laptop / pda and smart phone.

2 Furthermore, IWBs seem to reinforce traditional pedagogies. They do not in themselves afford learner autonomy in the way that laptop, or even desktop, PCs do. The long-awaited ‘transforming pedagogy’ for ICT (Somekh & Davies, 1991) clearly requires more than regular use of ICT by teachers; it requires a change in pedagogical knowledge and beliefs. (Kennewell, 2004: 17)

And the images and texts that reach us through the (often American-style) marketing of suppliers seem to reinforce this "traditional" teaching model: they are evidently targeted at (the basic instincts of?) teachers but do not—in my opinion—trigger associations with the current educational climate (in the Netherlands, at least).
On the other hand - if you focus on the medium as a tool designed to support whole-class activities - the question arises: 'What exactly is the added value that IWBs should provide compared to using 'normal' facilities such as a projector connected to a computer?' And, indeed, if IWBs are merely used as presentation tools there seems to be hardly any added value. This can only be created when using specific features / properties of the IWB. With regard to the added value of the IWB versus 'traditional' projection issue, we found observations such as the following:

- Digital text is not possible on a traditional whiteboard. Using your finger or the mouse to make text is not possible, you'll have to type which goes at the expense of spontaneity and flexibility (Kennewell, 2001) because it takes more time.
- You cannot save materials, elaborated during the teaching process, for future use (Longman & Hughes, 2006), thus foregoing opportunities to deconstruct them for process analysis (Kennewell & Morgan, 2003) or make them available for reference in a virtual learning environment (VLE), for example, for absent pupils.
- You will actually not be physically near the board as you need to behind your computer. This comes at the expense of interactivity between teacher and students or between students themselves.
- Switching between the flipcharts to be presented can be done quickly, in contrast to, for example, the linear constraints of PowerPoint presentations.
- You'll need to collect useful files yourself to develop a collection of educational material. This will be a more challenging task as the various useful tools that are standard in the IWB software will not be available to assist you (Zadelhoff, 2007).

Despite these points Moss et al. (2007) in their final evaluation of an IWB project around London (Primary Schools Whiteboard Expansion Project, 2004-2007) conclude: …This research is unable to resolve whether IWBs have more potential in the classroom than the use of data projectors and networked peripherals (Moss et al., 2007: 8).

2.2 Pros and Cons of IWBs
In the present study, researching added value and experiences with IWBs, we also include the use of software tools that come with IWB brands such as Notebook (Smart Board) or e.g. ActivStudio (ActivBoard). The diagram below provides an overview of how IWB functionalities can be used to support the provision and processing of information.

<table>
<thead>
<tr>
<th>Ways to deal with information</th>
<th>IWB features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capture Information</td>
<td>Taking a ‘photograph’ of (parts of) the page being displayed. Cut and paste from other software such as MS Word, re-use of parts of Web pages etc.</td>
</tr>
<tr>
<td>Emphasize</td>
<td>Ticker Tape function (word moves continuously across the screen). Marking text parts with colour, or proviging focus with a ‘spot light’.</td>
</tr>
<tr>
<td>Save</td>
<td>Save as presentation page for use later during lesson or future use. Save as file or link.</td>
</tr>
<tr>
<td>Annotate or Edit</td>
<td>Add text, arrows or lines to text or image displayed. Emphasize text with marker. Create gapped texts. Drag objects to an appropriate location or to sequence text fragments.</td>
</tr>
<tr>
<td>Links</td>
<td>Links between flipcharts. Create links to websites, stored files (Excel, PPT etc) or software applications e.g. for mind mapping.</td>
</tr>
</tbody>
</table>

(Adapted from Beauchamp & Parkinson (2005)
Most conclusions from literature reviews such as the BECTA report (2003) and the study "Interactive whiteboards and Learning: A Review of Classroom Case Studies and Research Literature (SMART Technologies Inc., 2004) are confirmed by other and also more recent studies. Below we summarize the reported benefits of IWBs:

- allows flexible use of curriculum-wide applications for all ages (Smith A, 1999; Latham, 2002)
- provides more teaching time because teachers can use web-based and other resources more efficiently (Walker, 2003)
- more opportunities for interaction (Cox et al., 2003), cooperation (Painter, Whiting & Wolters, 2004) and discussion in the classroom (Levy, 2002), especially in comparison with other ICT-use (Gerard et al., 1999).
- provides focus (cinema effect) (Smith et al., 2005), contributes to concentration (Beeland, 2002; Stuart, 2004; Solvie, 2004; Kennewell, 2004) and motivation (Levy, 2002; Longman & Hughes, 2006:16)
- more varied and dynamic use of resources such as software and internet (Somekh et al., 2005; Higgins et al., 2005; Somekh, Haldane et al., 2007)
- the increase in lesson pace resulting from IWB use contributes to the speed at which lesson content is covered which in its turn provides more opportunities for elaboration (Walker, 2002), repetition of content and test preparation (Cuthell, 2006)

Inspired by Beauchamp and Parkinson (2005: 97) we summarize further benefits from various perspectives, starting with the learner’s perspective:

- because there are more opportunities to participate and cooperate (Balanskat et al., 2006: 6) lessons are experienced to be more attractive (Balanskat et al., 2006: 39)
- clear, efficient and dynamic presentations promote engagement and motivation (Cuthell, 2006; Wall, Higgins & Smith, 2005; Schuck & Kearney, 2007: 25; Fisser & Gervedink Nijhuis, 2007: 26;)
- learners manage to understand more complex concepts by physically handling related objects and representations (Bell, 2002; Higgins & Smith, 2005; Somekh, Haldane et al., 2007; Edwards et al., 2002). Conceptualisation is helped by concurrent verbalisation of thoughts (Glover et al., 2007: 17)
- multi-modal and kinaesthetic possibilities (Miller & Glover, 2006) deepen learning and promote metacognition (Wall et al., 2005) particularly when materials used are specifically designed for particular lesson phases (introduction, interim comprehension checks, debriefing and reflection) (Glover et al., 2007: 14)
- enables learners to be more creative when making presentations for fellow students and thus promotes their self-confidence3 (Levy, 2002; Cox et al., 2003)
- storage and printing of IWB-materials takes away the necessity to copy content and facilitates reuse and repetition (Walker, 2002; Fisser & Gervedink Nijhuis, 2007: 26)

Some of these research results led Longman and Hughes (2006) to point out the importance of more research into the views of the students as ‘end-users’ on the impact of ICT in the classroom.

---

3 The implicit appreciation of learner comments communicated by teachers by paying attention to and reconstructing them in the form of annotations to (replays of) flipcharts contributes to involvement, motivation and self-confidence (Glover et al., 2007: 19).
When asked for their opinions about the IWB pupils are unanimous in regarding it as fun and "...much better than a flipchart ..." or an "... old type of blackboard ...". Correcting errors, moving things about, selecting, changing, and undoing are all regarded as great features. (...) When asked to compare the IWB with a flip chart a pupil responded with confidence: “You can’t type on it, you can’t drag pictures onto it and you can’t play games on it very well, you haven’t got the internet and it isn’t very good in the dark either”. (Longman & Hughes, 2006:14-15)

(...) Our data let us see a little more of the pupils’ perspective than of the teachers’. This we found exciting and realised that it is important to gather more data about how pupils see this type of technology affecting their classroom life. In our data the pupils demonstrate an easy and ready use of key ideas about ICT – dragging, undoing, finding and displaying, etc., and how easily they list them when asked to give examples of how the IWB helps them to learn. A particularly interesting detail that emerged from this data is the value that pupils place on the repeatability of demonstrations and illustrations used by the teacher (Longman & Hughes, 2006:17)

In our sources we found the following points about IWB use as benefits specifically for teachers:

- support for and ease of integration of ICT in classroom teaching (Smith H, 2001; Balanskat et al., 2006)
- offers flexibility and saves time because a wide range of web-based resources can be applied, adapted and customised content can be reused (Kennewell, 2001; Kent, 2006: 3)
- makes teaching more stimulating for the teacher (Barry & Smith, 2005) partly because the availability of source materials facilitates addressing diversity” (Glover et al., 2007: 13) and more rewarding (Lee & Boyle, 2003; Richardson, 2002) because learners show more task-oriented behaviour
- Moss et al. (2006) and Adrian (2004) also reported better behaviour
- Storage and printing capabilities support reuse of lesson series (Walker, 2002)
- Contribution to the (eventual) reduction of workload because materials can be easily shared (Glover & Miller, 2001; Balanskat et al., 2006: 37; Kennewell, 2004)
- Encourages and helps to prepare lessons (structuring information, planning comprehension checks) (Latham, 2002; Solvie, 2004; Smith et al., 2005)
- Simplifies the deployment of resources and media in the teaching process: less hassle with different devices (Glover et al., 2007: 13)
- Allows replay of events and reviews of processes e.g. in animated demonstrations of models and phenomena (Berque, 2004; Miller & Glover, 2006)
- inspires teachers to change their teaching methods and facilitates the adoption of other ICT applications (Balanskat et al., 2006: 45)
- IWB use contributes to teachers’ professional development (Smith A, 1999; Cuthell, 2006; Smith et al., 2005).
- Allows replay of events and reviews of processes e.g. in animated demonstrations of models and phenomena (Berque, 2004; Miller & Glover, 2006)
- inspires teachers to change their teaching methods and facilitates the adoption of other ICT applications (Balanskat et al., 2006: 45)
- IWB use contributes to teachers’ professional development (Smith A, 1999; Cuthell, 2006; Smith et al., 2005).
- Storage and printing capabilities support reuse of lesson series (Walker, 2002)
- Contribution to the (eventual) reduction of workload because materials can be easily shared (Glover & Miller, 2001; Balanskat et al., 2006: 37; Kennewell, 2004)
- Encourages and helps to prepare lessons (structuring information, planning comprehension checks) (Latham, 2002; Solvie, 2004; Smith et al., 2005)
- Simplifies the deployment of resources and media in the teaching process: less hassle with different devices (Glover et al., 2007: 13)

Broadly speaking, these results are also reported in the MirandaNet Promethean research (Cuthell, 2006). This study consists of a compilation of action research reports by practitioners in a number of countries (China, Mexico and Africa)

Disadvantages reported include the cost factor and matters of a more technical nature like the heat and short life of data projector lamps and

---

4 With reference to the use of ICT to address diversity issues 2/3 of the respondents in a recent BECTA study (2007) considered IWBS to be an essential tool.
the limited accessibility of certain types of IWBs. Further negative points are listed below:

- There are physical/financial limitations: often, not all classrooms in a school are equipped with an IWB (Stuart, WCCE Conference, 2005)
- The centrality of the teacher is often reinforced (Stuart, 2005; Vandeweyer, 2007)
- The novelty wears off after a while, (observation in secondary education by Moss et al. (2006)) (Levy, 2002; Ball, 2003; Gray et al., 2005: 43; Vandeweyer, 2007).
- Avoidance due to lack of confidence (Duivenvoorden, 2006) and irritations due to technical failure or lack of IWB skills with teachers and/or learners (Hall & Higgins, 2005)
- A higher lesson pace, above reported as a benefit, may well also be a disadvantage, especially for weaker students (Kennewell, 2004) and students with (physical) disabilities (Somekh & Haldane, 2006).

Moss et al. (2007) observed in a number of case studies that multimedia and increased lesson pace were used for discipline purposes rather than to support the learning process.

Like multimodality and technical interactivity a fast paced pedagogy is not necessarily good in and of itself. There can be as significant pedagogic value in slow board work, or real time board work, when it is used to realise a specific pedagogic aim. Indeed, it could be argued that real time text creation is easier to follow for a student than a pre-prepared text with no clear reading path (Moss et al., 2007).

It appears that when teachers have access to an IWB, the amount of time spent on whole-class activities increases at the expense of time for group work (Wood, 2001; Smith et al., 2006; Stuart, 2005; Higgins, 2005). But Somekh et al. (2007) note that as long as IWB use is educationally adequate less group work does not need to have negative effects.

At a more abstract level Kennewell (2006) summarizes the educational potential of IWBs in three roles: advisor, organiser and facilitator. The first function is associated with provision of information in the form of prepared ‘outcomes’ of a debate, spontaneous or planned Internet search activities and working with simulations. As organiser, the IWB offers the opportunity to work with unpredictable results of specific activities, e.g. games. This gives the teacher the opportunity to participate and, as an equal partner and in an authentic way, discuss problem solving strategies with the learners.

Finally, the facilitative role offers a less rigid structure to provide focus or do activities which involve making choices (e.g. decide on the wording of annotations, do matching tasks) where the teacher can coach the discussion about options or learners can help each other in making choices.

3. Further analysis of some specific aspects
Below we elaborate on some specific aspects and summarize the main findings from various sources with respect to these themes.

3.1. Engagement and motivation

A number of reports including Zadelhoff (2007) and Balanskat et al. (2004) shows that teachers find IWB-use motivating because it can provide easy access to digital materials to enrich their lessons.

They notice that learners are more engaged because the board is large and the contents clearly visible.

The multi-media and interactive possibilities help pupils to recognize relationships (Smith et al., 2005: 67) for example, because related content is presented in the same colour. In fact, younger generations of students have come to expect presentation of information to be visually enhanced (Zadelhoff, 2007; Levy 2002).

And indeed, it is easier to understand the force of a volcano eruption when the information is accompanied by an animation or a film fragment.

In addition, the conditions for engagement can be further optimized by using IWB tools to provide even more focus by capturing specific moments of the process for replay or zooming in on particular phenomena.

In this respect it should be noted that some authors emphasize the importance of sustainable educational effects by putting the technical features at the service of activating methods and teaching styles.

...Clearly the IWB is a lot more exciting than the blackboard and overhead projector, and pupils will be curious to find out about its functions and capabilities. As a result, they may pay more attention than in the past. However, once the teacher has exhausted all the IWB routines, and the ‘wow’ factor has passed, these pupils may revert to less attentive behaviour. (Beauchamp & Parkinson, 2005)
3.2 Interaction

For a hygienic discussion about the added value of IWBs with respect to ‘interactivity’ a detailed definition of this concept is in place. Smith, Higgins, Wall, and Miller (2005: 94) argue that the interactive potential of IWBs in particular offers opportunities to create educational added value, supported in this by other researchers, among which Bell (2000), Glover & Miller (2001) and Greiffenhagen (2000).

Several authors including Kennewell (2007) and Cutrim Schmid (2006a) make a distinction between interactivity in a technical or physical sense (board functionality such as the production of sound when you touch a picture) and the promotion of cognitive interactivity (question - answer, comprehension check).

…However, despite the apparently passive nature of pupils’ experience during much whole-class teaching, pupils are still carrying out activities. These activities may be purely cognitive or perhaps metacognitive – apprehending, comprehending, memorising, assimilating, reflecting - for periods of time during whole-class teaching, but nevertheless they are activities and their actions can still be afforded or constrained by features of the setting, including ICT. Furthermore, the most effective teachers stimulate the cognitive engagement of pupils by posing questions and requesting contributions in order to minimise the duration of periods where they are behaving passively. (Kennewell, 2007:3)

Hughes and Longman (2006) note that within the latter category also qualitative differences can be distinguished such as the use of closed versus open questions.

A third type, finally, is the so-called socio-cognitive interactivity (co-construction of knowledge, encouragement of reflection, brainstorming between teacher and student and among students (Latane, 2002). The views of the teacher about what interaction means and how she defines her role in this impacts heavily on the way the IWB is actually used (Goodison, 2003: 557).

Research by Somekh et al. (2007) shows that teachers, once they are used to the technology, gradually change the 'traditional' way they use the IWB initially in such a way that it supports more socio-cognitive interaction.

Smith et al. (2005: 68) report similar observations:

…A number of positive themes also emerge from the analysis of classroom interaction. There was an increase in some kinds of interaction, such as open questions or aspects of questioning where the teacher pursues pupils’ responses ('uptake' questions) or asks them to develop or explain their ideas ('probes') which are associated with effective teaching and learning (e.g. Nystrand and Gamoran, 1991; Muijs and Reynolds, 2001).

For further details of concepts in the discussion of interactivity and research into the educational value of IWB usage in this context consult e.g. Muijs & Reynolds (2001), Kennewell (2005), Tanner et al. (2005) and Cutrim Schmid (2006a). Further increase in interactivity can be realised through the employment of additional devices.

For instance, at any phase of the lesson comprehension checks can be done at an individual level by providing learners with response devices, so-called clickers (Moss et al., 2007).

If well designed (for example, by also asking learners to provide arguments for their answers) the checks, questionnaires or polls mediated by clickers can contribute to further engagement and deepen the processing of content5 (Cutrim Schmid, 2006c; Cutts, 2004).

A visualiser6 or document camera can be used to organise a discussion on the basis of some pupils’ written homework; with a webcam the

---

5 The trouble is from the lecturer’s point of view that the nature of this learning cannot be observed. We cannot see whether our students are understanding or internalising the ideas being presented to them. Interactive teaching involves the use of strategies that stimulate feedback from students. This is not just of benefit to the lecturer. Students learn much more effectively when they are active agents in their own learning, when they make their thinking explicit by words or actions, when they take ownership of ideas and information. Also, some learners will benefit from seeing other students demonstrate and explain their thinking and model how they arrive at their solutions

6 With the help of a visualiser enhanced digital projections can be made of physical objects. In this way students’ written work can be discussed or the operation of a specific device can be demonstrated.
handling of equipment during a laboratory test can be shared with the whole group.

Using a *slate*, a tablet with a wireless connection to the IWB computer, students can also contribute from their seats, e.g. by annotating, changing or adding content to the flipchart that is under discussion.

This sharing of individual student work in the group and using the Internet to access reality outside the classroom are referred to by Longman and Hughes (2006) as examples of a connectionistic approach.

...Connected teachers encourage learners to: see interrelationships in knowledge; connect new knowledge to its roots in old or prior knowledge (rather than constructing anew all the time as perhaps constructivism might construe the process); and encourage social connectedness (among other things through the use of networked technology) to help achieve this. In the present data, the use of the tablet illustrated how the individual pupil is connected to the whole class through the visibility of the activity on the IWB. The thinking is shared and is more likely to be owned by the group as a co-connected and co-constructed understanding. (Longman and Hughes, 2006:18)

Another advantage of tablet use is that it allows the teacher to move about freely in the classroom. And, in moments of unrest, can operate the board from arbitrary positions in the classroom. Greiffenhagen (2002) even believes that without these additional resources most IWB-use often simply amounts to ... a 'chalk and talk' style of teaching.

3.3. Learning results

According to Higgins (2005) the results in language, maths and science in primary UK school students improved after the introduction of the IWB. This is particularly true of writing in the native language and - in general- for underachieving students. It is, however, uncertain whether these effects can be attributed exclusively to IWB-use.

Balanskat et al. (2006: 27) and Smith et al. (2005) also have their doubts:
The impact of IWBs is harder to identify in terms of pupils’ learning. Initially it appears that there was a small but statistically significant gain in the IWB project schools’ attainment in mathematics and science after a few months of use by their teachers. However, for the next year group, who had been in classes where IWBs were used for at least a year and a half, no similar benefit could be identified. Smith et al. (2005:68)

As possible explanations for this outcome (unexpected according to both the students and teachers because they all felt the quality of the learning process had improved) they suggested either the possibly negative effect of written tests or the Hawthorn effect. Unlike Moss et al. (2007:9) Somekh et al. (2007) could report improved results, especially for maths and science, with those teachers who had managed – after approximately two years – to integrated IWB-use in their teaching methods repertoire.

There is a consistent finding across all data that the length of time pupils have been taught with an interactive whiteboard is the major factor that leads to attainment gains. This appears to be the result of the interactive whiteboard becoming embedded in teachers’ pedagogy: that is, when teachers have had sustained experience (around two years) of using an interactive whiteboard, they are able to change their teaching practices to make best use of its facilities. The qualitative data strongly support this. Somekh et al. (2007:4)

Kent (2006), reporting about 4 years of IWB use at his primary school in Australia, notes that school results for national standard tests clearly improved, with noticeably positive attainment records, particularly of special educational needs (SEN) pupils. Miller et al. (2005) and Knight, Pennant & Piggott (2005) argue that IWBs, when their interactive potential is fully exploited, can create better conditions for learning (mathematics) compared to ‘standard’ black- or whiteboards (Smith et al., 2005:68).

3.5. Learning styles, special education

As we remarked in Section 2.2., one of the elements of educational added value is the support IWBs can provide for scaffolding various learning styles and addressing diversity issues (Bell, 2002; Cuthell, 2003, Burden & Sietniekas, 2004, Glover, 2007:13).

Technical features such as the possibility to combine images, text and sound and the support for tactile activities such as drag-and-drop contribute to the processing of information (Salinitri & Smith, 2002; Carter, 2002; Sessoms, 2007) and engagement and concentration, particularly with younger and SEN pupils (Ofsted, 2005; Zirkle, 2003)

...The degree of engagement and participation was felt to be increased; this was particularly important for the less able children. One way in which this was achieved was by calling pupils up to the board to interact with the material; it was important that the younger children were able to drag words and images as objects rather than writing or drawing. One teacher saw the ‘hands-on’ interaction was very valuable for this pupil, but also thought that all the other pupils were cognitively engaged in the same task – indeed, they were considering whether or not the selected pupil might complete the task successfully, how they would do it themselves, and what mistakes the selected pupil might make. (Kennewell, 2004:12).

Because there is no keyboard needed it is easier (Goodison, 2002; Thomson et al., 2003) and motivating (Somekh, Haldane et al., 2007) for young children and students with physical disabilities to
use computer technology. Blanton et al. (2000) and Cooper & Brna (2002) report, with some reserve, an increase in concentration ability and positive effects in the training related to social skills and behavioural problems of students with learning and educational problems. Somekh et al. (2007) confirm these conclusions.

On the other hand, they attribute only a limited improvement in learning outcomes in literacy and numeracy to the IWB use in whole-class sessions. In contrast to the use in small groups (n <4) that appears to have resulted in significantly better scores for those subjects (including dyslexic children).

As mentioned above, the use of IWBs also has educational disadvantages - particularly for students with physical disabilities, such as a higher lesson pace. Somekh et al. (2007), for example, point out the fact that this impedes the work of teaching assistants when supporting blind students in the processing of the contents on the board. Consequently - with a view to the positive impact of working in small groups - Somekh et al. (2007) stress the importance of involving teaching assistants in IWB-related professional development activities.

3.6 IWB materials

As we also found in our own research the availability of textbook-independent teaching materials, especially designed for IWB-use (both commercial and open source) is still very limited (Somekh et al., 2007). Most of it is intended for use in primary education. For secondary education, quantitatively speaking, science is better off than the social sciences, there is relatively little for English as a first language, but this amount is still ample compared to modern languages (Gray et al., 2005: 42). This conclusion is also partly corroborated by UK teachers' views on the challenge of finding suitable materials.

The majority of the current collection of freeware materials made available by hardware suppliers such as Smart Board is related to the Canadian and American curriculum. Recently the number of commercial initiatives that produce textbook-independent materials for use on a particular IWB brand or board-specific software has started growing.

Just under a third of teachers (30%) reported that they find it difficult to find suitable IWB resources. The same number of teachers report that they find it easy to find resources. English teachers were most likely to find it difficult to access IWB resources. It is unclear however if this reflects a lower availability of IWB resources for English teaching or simply lower technological confidence amongst English teachers. In our sample, the Maths and Science teachers are most likely to report that they find getting IWB resources straightforward (Moss, 2007: 24).

As yet teachers solve this shortage of materials by using and exchanging their own products (generally mostly PowerPoint content). Hardware suppliers encourage this exchange by offering facilities for storage and community development. Educational software such as Encarta or specially designed websites are also used. According to Zadelhoff (2007) and Louwers (2007) various educational publishers are developing IWB materials to support their textbooks. In first generation materials this usually boils down to
providing electronic versions of pages from the currently available text- or workbook. This situation is expected to change for the better when updates or new publications come available.

In the meantime many schools and departments have started producing their own materials.

The teachers involved face the challenge of value creation with text types (images, graphs, exercises (work)books) that have not been designed specifically for use on a IWB. In practice, most materials (including those of the publishers) make but very limited use of the interactive capabilities of IWBs (Jewitt, 2007).7

Another impediment for the exchange of (quality) materials is the intellectual property issue.

So there is still much duplication of work, also at enterprise level, because the currently available commercial products can usually only be used on a specific IWB brand.

But there is also good news: there is a BECTA initiative, launched in August 2007, to develop a standard file format for IWBs in collaboration with interested industries. The question, however, is how long it will take to realize compatibility, given the huge commercial interests at this stage of market development (estimated size in 2008: 1 trillion (Davis, 2007).3

3.7 Training and professional development for teachers

Many authors (Smith et al., 2005; Ofsted, 2005) emphasize the importance of good training. As Kennewell & Morgan (2003: 2) point out:

...' In order to exploit all the features of these devices whilst interacting with a class, teachers need to develop a number of new techniques to reach automaticity and to gain an understanding of the role of

---

7 One thing that was surprising was that over 70 percent of teachers make their own materials for the interactive whiteboard. In a way it's nothing new to say that the materials used in a classroom shape the pedagogy of the classroom. But what was interesting was that the things that got displayed on the interactive whiteboard - and this is true with a lot of commercial materials as well - tend to be designed around familiar practices, familiar kinds of texts and materials. So the worksheet, for example, migrates to the interactive whiteboard.

Kennewell (2007) emphasizes that initial training and professional development is extremely important because what a teacher actually does with an IWB is obviously more important than the device itself, as in fact true for any device. In comparative research on teaching practices and attainment results under the condition 'with and without IWB' Moss et al. (2007) and Higgins et al. (2005) showed that no major changes occur in teaching methods and practices of the teachers involved and that in fact:

In the majority of lessons observed the nature and quality of pupil learning was consistent with practice observed in classrooms without IWBs:

• In many instances the texts in use on the IWB replicated the features of texts associated with existing technologies (TV; computers; blackboard) and often shared the form and function of traditional textbooks and worksheets
• Patterns of pupil-teacher discourse were largely unchanged
• Technical. or .physical. interactivity with the IWB was seldom harnessed to produce significant shifts in understanding. Moss e.a. (2007:44)

Partly based on research of Higgins (2006) and Nordkvelle & Olsen (2005) also Somekh & Haldane (2006) point to the fact that teachers apply their current teaching style and practices when they start using IWBs:

... For example, it has been found that IWBs tend to reinforce established styles of whole-class teaching - sometimes extending the teacher’s ‘whole-class mode’ unproductively rather than promoting new, innovative teaching approaches (Higgins, 2006).

... As with other uses of information and communications technology (ICT) in classrooms, IWBs are often made to fit ‘pre-existing instructional practices’ (Nordkvelle & Olsen, 2005).

Kennewell et al. (2007) conclude that transformation of education in terms of more independent and individualized learning is not widespread in the UK. Rather, there appears to be an incentive for traditional teacher-centered approaches.
Factors that contribute to effective use include the availability of adequate conditions so that teachers can develop self-confidence and can integrate IWB use into their educational practice (Levy, 2002; Glover & Miller, 2001). Key elements here are aspects such as time (Glover et al., 2007: 17), adequate access to IWBs, sample materials and technical support (Glover & Miller, 2002a; Agterberg and Teeuwes, 2007: 17). How training and professional development programmes can best be designed is a matter for further research. The relevance of some design features, however, can already be established.

Thus it is clear that teachers should have adequate ICT skills (Duivenvoorden, 2006). And a subject-specific component is of great importance. The training must be tailored to the individual needs of teachers (Levy, 2002) so that they can become familiar with methods and techniques relevant to the subject that they teach. After all, disciplines have their specific educational culture and pedagogies (Haldane & Somekh, 2005:13).

Students, too, must learn how to work with IWBs to allow active participation and overcome possible embarrassment about their technical skills (Glover et al., 2007: 17). Teachers need a clear understanding of the concept of ‘interactivity’ and develop a common frame of reference in this respect (Glover, 2005: 7). Also for use in their respective research projects Miller et al. (2004), Cuthell (2007) and Vincent and Jones (2007) developed descriptions of teacher competencies and developmental stages teachers go through (Haldane & Somekh, 2005).

Miller et al. (2004) defined three stages in competence development process with respect to IWB use by teachers:

a) to visually support teacher-centred knowledge and information transmission (supportive didactic)

b) to stimulate student responses through the use of verbal, audio and visual stimuli and graphical representations of concepts (interactive)

c) like b) but more flexible, with even more intensive participation by students through exploratory activities and group work using a mix of self-developed materials and Internet resources (enhanced interactive).

It is self-evident that, especially for this latter, more process-oriented approach, thorough subject knowledge is indispensable. Indeed, it may well be the decisive factor to allow flexible handling of pre-prepared materials as the following observation in primary education shows:

…The flow of the lesson was not purely linear; teachers moved backwards and forwards through the content and process of the lesson by scrolling documents, selecting powerpoint slides, and ‘flipping’ through pages of the ‘flipchart’ software provided with the IWBs. They also responded to points arising from the class, although some opportunities were missed. This may have been caused by a reluctance to depart from the highly detailed planning employed when their subject knowledge was limited. (Kennewell, 2004: 12)
Implementation strategies that foster informal cooperation and a buddy approach have shown to be effective forms of professional development (Cuthell, 2006; Kennewell, 2004).

Developing multimedia teaching materials is a significant addition to workload in the early stages, though preparation time decreases once a range of materials exists. The expectations that the whiteboards engender in pupils, however, put pressure on teachers to constantly improve the presentation and content of lessons. The capacity to share resources via the school network and internet could reduce workloads, but evidence suggests that this is currently underused (Glover and Miller, 2001).

Moss et al (2007: 59) also believe that an exploratory, trial-and-error approach where experiences are shared, co-ordinated by an enthusiastic colleague in their own school, is a more effective training model than the demonstration and training of a set of IWB techniques, for example drag-and-drop or hide-and-reveal. The more so because this latter model is based on the false assumption that there is well-defined and exhaustive body of knowledge of all the possible applications of the IWB technical features.

Training of board techniques must therefore be linked to educational theory and practice (Miller & Glover, 2007) and it is for this reason that Somekh et al. (2007) view accredited training programmes for trainers and teachers as indispensable.

Successful CPD is most likely to be effective if it supports individual teachers, exploration of their current pedagogy, and helps identify how IWB use can support, extend or transform this. Discussion of the relative strengths and weaknesses of different ways of using the technology for particular purposes should be part of the on-going work of a department.

Somekh (2007) stresses the importance of training and continuing professional development (CPD) with a view to the gradual improvement of student results.

The training of pre-service teachers (in training) appears to be still in its infancy, as also reflected by the limited number of publications about this topic. From a survey involving a cohort of primary education student teachers Kennewell and Morgan (2003) report a positive attitude towards presentation technologies. Their research also showed that young teachers who currently start working in schools equipped with IWBs report to dearly miss a dialogue in their training about (subject-specific) IWB-related pedagogy and/or about possible added value of IWB use.

As already noted by other authors (Graham & Thornley, 2000; Koenraad, 2005: 4) also Condie and Munro (2007) argue that experiential learning, in particular for the development of competencies in the field of educational computing, is of vital importance in teacher education. Student teachers should be offered practical experiences with the integration of ICT in education. This implies that—as students - they have experienced innovative (subject-specific) computer use, are encouraged to experiment during internships and get competent mentoring.

Although Glover et al. (2007: 15) report that teachers are quick to realise that having and sharing a collection of teaching materials offers great advantages Somekh et al. (2007) recommend to postpone the development of such a resource till after the exploratory phase as described above.

8 This small number is also partly due to the fact that IWBs were (still are?) not widely used in (UK) teacher education: at the time these organisations were not included in the national grant programme.
Trainee teachers need to have the opportunity to [...] explore potential applications in the context of their own teaching practice (Graham & Thornley, 2000). However, this necessitates teacher educators being competent and confident with ICT resources and the associated pedagogy themselves (Yildirim, 2000). Teacher educators will need to be much more than expert users of ICT; they will need to be ‘specialist educators who can make students secure in the range of pedagogical uses soon to be required of beginning teachers’ (Simpson et al., 1999). (Condie & Munro, 2007: 17)

4. Conclusions

The results of the currently available research present a predominantly positive picture of the educational possibilities of IWBs to enhance (whole-class) lesson phases such as instruction, presentation, brainstorming and debriefing.

There is consensus on the contribution of this tool to three aspects of educational practice: the presentation of information and resources, the power of visualization in the interpretation of concepts and models, the facilitation of interaction and organization of activities with a whole-class focus.

On the other hand it is clear that the technology itself can not perform miracles and that the expected added value can only be realised with the help of the professionalism of the teacher.

Next to adequate training and professional development for IWB use to be successful educationally (Fisser & Gervedink Nijhuis, 2007: 27), other factors are relevant such as the school culture, the implementation strategy (Wiezerei, 2006), leadership and management support (Lee, 2004). In short, the usual factors involved when introducing ICT applications in education.

As yet, the key questions: “Does the use of IWBs lead to educational innovation or merely to optimisation of traditional education? “ and “Do IWBs contribute to better school results?” cannot be answered with certainty. The opinions expressed about these issues vary considerably in the papers studied.

Having determined that ... "the use of the IWB may be the most significant change in the classroom learning environment in the past decade ..." Higgins et al. (2007) conclude that:

The key issue emerging from this analysis is that although the IWB may alter the way that learning takes place, and that the motivation of teachers and pupils may be increased, yet this may have no significant or measurable impact on achievement. The research literature has yet to demonstrate the direction that teachers need to move to ensure that the proven changes the IWB can bring about in the classroom discourse and pedagogy are translated into similar and positive changes in learning (Higgins et al., 2007: 221).

Other researchers (Miller & Glover, 2007; Somekh et al., 2007) have shown effects and expect positive results in due course if adequate training is provided and teachers are allowed sufficient time to adopt the new technologies Fisser &. Gervedink Nijhuis, 2007: 27). There is still too little empirical, qualitative, longitudinal and subject-specific research available for firm conclusions, perhaps with mathematics as an exemplary exception. For similar conclusions on these matters see Schuck & Kearney (2007: 13) and Moss et al. (2007). Rutt (2007) has a number of suggestions on what type of follow-up research is needed.
Somekh et al. (2007) and Jewitt (2007), too, point out that possible effects can only be attributed to IWBs after a considerable period of time.

The ability of the technology to adapt to existing pedagogy at this stage in the implementation cycle suggests that judging any distinctive contribution that IWBs can make to pupil learning will be a long-term process dependent on on-going exploration of what the technology can best be used for. (Somekh et al., 2007:7)

Also, we should realise that many of the conclusions reached are based on research done in primary education, especially in the curriculum areas numeracy and literacy and that many studies were carried out during the first phase of implementation. This should be taken into account when drawing conclusions from the available results.

Furthermore, it should be remembered that the majority of the conclusions reported in this review study were based on research in other countries (UK, Australia, America, Canada), each with its own specific educational approach and (school) culture, and therefore possibly not fully applicable to the Dutch situation or other countries for that matter.

One of the more consistent findings is that the adoption process of IWBs by practitioners is a lot more fluent compared to the integration of Internet and the use of subject-specific software. Especially where teachers with adequate ICT skills and a positive attitude towards the use of ICT in education are concerned (Duivenvoorde, 2008:11) ⁹.

Some authors (Smith A, 1999; Heppel, 2004) see this as an advantage because, indirectly, IWB-use appears to contribute to increasing teachers’ ICT skills. And this, in its turn, improves the chances that teachers also start using other ICT applications and in this way contribute to the further integration of ICT in education (Somekh et al., 2007).

“It strikes me that the importance of whiteboards is that they are one of the first pieces of IT technology which are ‘owned’ by the teacher as opposed to the learner - good teachers of course will share it with their pupils - it is this ownership and place at the heart of teaching (as opposed to learning) which excites teachers - and rightly so in my view.” Martyn Wilson, Hampshire County Inspector for IT

With respect to this issue Hall en Higgins (2005) argue that:

‘...Indeed it is reasonable to conjecture that it is precisely because the IWB is so suited to supporting whole-class teaching that it has been adopted so rapidly in comparison with more personal technologies which integrate less readily into traditional teaching methods. This may lead to the technology merely being used to reinforce current teaching approaches, rather than supporting a transforming pedagogy.’

Furthermore Moss et al. (2007:47) note that differences in teachers’ appreciation of IWBs can also be related to the particular school subject they teach:

The case studies suggest that the relevance of IWB technologies was more easily recognised and realised in Maths and Science than in English, where the benefits of the technology seemed less immediately apparent. (Moss et al., 2007:47)

It appears to take an exploratory attitude to realize the potential and added value of IWBs. Implementation is more successful if the possibilities of IWBs are explored in collegial collaboration (Fisser & Gervedink Nijhuis, ⁹ Duivenvoorde qualifies her research results by pointing to a possible unrepresentativeness of the cohort of respondents involved (Duivenvoorde, 2006: 13).
In this respect Cutrim Schmid (2006c: 60) and Hughes & Longman (2005: 11) emphasize that learners should also be involved.

An interesting action research study (Kennisrotonde, issue 063) in this context is the development of IWB-related pedagogy explicitly driven by the educational principles (Dalton-education) of the school involved (the Omnibus, Almere).

Student-centered methodologies are being developed through experiments where (small groups of) pupils use IWBs as a ‘mind tool’ (Kirschner & Wopereis, 2003) and to present results of groupwork. A first, interim report shows that students already have defined some concrete and practical applications.

The main threat to the effectiveness of that process are the established views of the (experienced) teachers based on previous experiences with media in their own teaching practices (Burden, 2002). Data from recent research on ICT use in the Netherlands (Gennip, Smeets & Marx, 2007) suggests that it will be a while before IWBs change teaching practices in innovative ways. One reason being that teachers—both in primary and secondary education—appear to apply activities targeted at transfer of knowledge more frequently than methods to stimulate knowledge construction. Besides, in general, these knowledge transfer activities are not supported by ICT (Gennip et al, 2007: 13). This leads us to expect that the impact of IWBs in education will be restricted if teachers do not sufficiently realize (Glover, 2005: 99) that for real interactivity to take place specifically designed materials (Stranders, 2008: 58), dialogical skills (Mercer et al, 2007) and appropriate methodologies are needed.

The case studies revealed over time the process of IWBs becoming embedded through initial adoption and ‘fit’ with existing pedagogies, and later, to varying extents in different classrooms, enabling/encouraging the development of new social practices. These more fundamental changes occurred through the activities of both teachers and children as they experimented with new ways of using the board, through a process that was often challenging for the teacher and is best described by Wertsch (Mind as Action 1998) as ‘the tension between agent and tool’. The changes were always closely related, however, to the teacher’s existing pedagogic orientation, and extended and enriched the existing levels and nature of interactivity rather than transforming didactic teachers into child-centred teachers (my italics).

One great benefit of the board, however, was to enliven and enrich didactic pedagogy so that teachers who may previously have found it difficult to sustain children’s attention were able to convey information and concepts more effectively. In some classrooms we saw clear evidence of gains in children’s sense of positive identity; and in others the use of the internet on the IWB appeared to assist teachers in bringing the outside world into the classroom to create more authentic contexts for ‘situated learning’ (Somekh, 2006)

And – to conclude – the results reported in this review provide, to us at least, yet another confirmation of an old adagium about the integration of ICT in education: ‘It’s not so much the program: more what you do with it […]’ an observation made in 1986 by Chris Jones about a piece of software for language learning, which he included in the title of one of his papers.


"...Pupils suggest to use the board during Music lessons, for spelling and reading in groups, to present groupwork and watch film fragments and for remedial teaching. On the other hand they are also critical and expect some pupils to lose concentration when IWBs are used all the time during lessons."
Literature

  http://www.techlearning.com/story/showArticle.jhtml?articleID=51209667
  http://www.ictopschool.net/infrastructuur/digtiaal-schoolbord/)(onderzoek_mrt2007)
  Schools in Europe. (European Communities, European Schoolnet, Belgium)
- Beauchamp, G & Parkinson, J. (2006). Beyond the 'wow' factor: Developing interactivity with the
  interactive whiteboard. School Science Review March 2005 86(316), 97-103
- BECTA (2004) Getting the most from your interactive whiteboard: a guide. Published on the Becta web site
  Whiteboards Help? Annual Conference of the Association of Information Technology for Teaching
  Education, Trinity College, Dublin.
- Bell, M. A. (2000). Impact of the electronic interactive whiteboard on students attitudes and achievement in
  http://teachers.net/gazette/JAN02
- Berque, D (2004) Fostering Classroom Engagement with Electronic Whiteboards, Tablet PCs, and
  DyKnow. Paper presented at EduCause 2004
  http://www.educuse.edu/Browse/705&ITEM_ID=207
  Interactive Whiteboard Technology in Special Education Classrooms.
  www.smarterkids.org/research/paper2.asp Augusta State University.
- Burden, K (2002). Learning from the bottom up – the contribution of school based practice and research in
  the effective use of interactive whiteboards for the FE/HE sector. Discussion paper presented at LSDA,
  the interactive whiteboard initiative in schools across WEAZ. The University of Hull, UK.
- Condle, R. & Munro, R (2007)The impact of ICT in schools – a landscape review (Coventry, Becta
  www.publications.becta.org.uk/display.cfm?resID=28
  221&page=1635
- Cooper, B. & Brna, P. (2002) Supporting high quality interaction and motivation in the classroom using ICT:
  the social and emotional learning and engagement in the NIMIS project
  http://www.becta.org.uk/page_documents/research/ict_pedagogy_summary.pdf Department for Education
  and Skills and Becta.
  contexts. Proceedings of SITE 2006. AACE Phoenix, Arizona
  AACE Phoenix, Arizona
  practitioners http://www.virtuallearning.org.uk/changemanage/ibw/Views%20from%20practitioners.pdf
- Cutrim Schmid, E. (2006a), Investigating the Use of Interactive Whiteboard Technology in the Language
  Classroom through the Lens of a Critical Theory of Technology. Computer Assisted Language Learning,
- Cutrim Schmid, E. (2006b). Promoting Higher Levels of Learner Active Participation in the Language
  Classroom with Interactive Whiteboard Technology. Presented at the IATEFL Learning Technologies SIG.
  Learning Technologies in the Language Classroom: A step closer to the Future. University of Cyprus
to Enhance Learning in the English Language Classroom. Computers and Education.
  Learning: the Potential of the ACTIVote System Component of Interactive Whiteboard Technology.
- Cutrim Schmid, Euline (In Press). The Pedagogical Potential of Interactive Whiteboards 2.0. In Thomas,
  M. (Ed) The Handbook of Research on Web 2.0 and Second Language Learning. IGI Global, USA
  response systems. In Proceedings of the 7th IASTED international conference on computers and advanced
  technology in education, Hawaii, USA.
  http://www.edweek.org/dd/articles/2007/09/12/02boar
d_h01.html
  Classroom. Micromath (Summer 2002): 33.
  en gebruik van digiborden bij de scholen van de Micromath (Summer 2002): 33.
  Implementatie en gebruik van digiborden bij de scholen van de


• Ofsted (2005), Primary National Strategy: An evaluation of its impact in primary schools 2004/05. London: Ofsted
• University of Windsor.
• Solvie, Pamela A. The Digital Whiteboard: A Tool in Early Literacy Instruction. Reading Teacher 57.5 (February 2004): 484-7.
• Morris Area Elementary School.
• Somekh, B et al. (2005) Interim Report to the Department for Education and Skills. Unpublished report from the SWEEP project


Wood, C. (2002); Interactive Whiteboards - A luxury too far? Teaching ICT 1(2).”

