Teaching for scientific literacy with an interactive whiteboard

by Karen Murcia

Developing scientific literacy drove the teaching and learning experiences provided to pre-service primary education teachers. Interactive whiteboard (IWB) pedagogy was used to engage and motivate these students' to explore science's role in making sense of our world and to understand key scientific concepts. Active science learning connected to social contexts was facilitated in workshops by the use of the technology. Using the IWB as a convergence tool facilitated the development of creative teaching resources that linked internet sites and on-line activities with hands on science investigations. It enabled fluid access to real life science contexts, supported a range of learning styles and when used appropriately placed students at the centre of the learning. This paper discusses a sample of the IWB science activities used and considers the potential of interactive whiteboard technology for contributing to the development of scientific literacy.

Introduction

The integration of information and communication technology into science classrooms is increasingly important for engaging and motivating today's students. In the developed 'minority' countries technology is integral to everyday life and for many people the phrase 'Google it' has become synonymous with 'I don't know but I can find out' Our students experience both the opportunity and demand to operate in a technological world in which they can connect via the internet to almost every corner of the world. To inform learning and teaching, Hackling and Prain (2006) conducted an analysis of a series of seminal Australian research and professional documents. The dominate characteristics of effective science teaching identified by them, were life and community relevant science learning experiences, active engagement and inquiry learning focused on outcomes that contribute to scientific literacy. In particular, they stated that in effective science teaching; 'Information and Communication Technologies (ICT) are exploited to enhance learning.' (p. 19). Educational research has suggested it is possible to integrate ICT effectively into classrooms with the use of interactive whiteboard technology (Riel, Schwarz, Hitt, 2002; Shenton & Pagett, 2007, Murcia & McKenzie, 2008). Interactive whiteboards are becoming increasingly popular in international educational environments. It was reported at the 2008 Australian Computers in Education Conference during a keynote address that interactive whiteboards are currently in over 99% of UK schools (Cox, 2008). The technology is now being introduced into Australian schools and educators are questioning how the technology can be used to support learning and teaching.

The installation of a *SMARTboard (http://smarttech.com/)*, interactive whiteboard (IWB) and a ceiling mounted data projector into a University teaching room provided an opportunity to explore the potential of the technology. The hardware enabled ICT practices to be integrated with pre-service primary teachers' science learning. This article presents a description of some of the interactive whiteboard activities developed and trialed with approximately fifty pre-service teachers in a Western Australian University's introductory science and primary science curriculum units. Each unit included a 12-week program of lectures and workshops. Both are compulsory units in the Bachelor of Education primary program. The described activities are framed here by a review of pertinent literature in the field of IWB pedagogy that considers the potential benefits of the technology. The aim of this paper is to share ideas and support teachers as they integrate interactive whiteboard technology into the science classroom.

What are the benefits in using an interactive whiteboard?

It is suggested by some researchers that contributing to the increasing popularity of interactive whiteboards is the suitability of the technology for whole class interaction and that it enables teachers to embed ICT into everyday classroom life (Haldane 2007; Murcia & McKenzie, 2008). Integrating ICT into daily classroom practice is possible with an IWB as it enables students and teachers to interact with all the functions of a desk top computer through the board's large touch sensitive surface. Any software on the computer can be interacted with at the board so it effectively becomes a port for incorporating a range of multimedia resources such as written text, pictures, diagrams, photos, video and online websites into whole group teaching and learning activities. In addition, the IWB software enables the creation of interactive activities designed to suit students' specific learning needs in any context. The multimodal functionality of the IWB provides students with the opportunity to express their ideas

not only verbally but graphically or pictorially and as such supports a range of learning styles.

Schuck and Kearney (2007) investigated the use of IWB in K–12 pedagogy in NSW primary and secondary schools. The teachers, students and school executives participating in this study identified the following benefits from using IWBs:

- Facilitation of reflective practice
- Ease of use
- Discovery and learning of new skills
- Value as a catalyst for teacher learning
- The visual nature of the board
- Immediacy, flexibility and convenience
- Interactivity
- The match to students' digital culture (p. 4)

There are different levels in these responses which is reflective of the shift in perspective from the school executives to the community of practice in actual classrooms.

What interactive science activities are possible with an IWB?

Teaching and learning for the development of scientific literacy with the use of interactive whiteboard (IWB) technology has become an area of interest for researchers and classroom teachers. Studies specifically on IWB use in science are currently limited. However, a study conducted in the UK by Hennessy, Deaney, Ruthven and Winterbottom (2007) did address pedagogical strategies for using the IWB in school science. Their specific focus was on teacher mediation between the IWB and the pupils. The participating teachers were found to exploit the dynamic and manipulative nature of the technology in order to 'focus thinking on key scientific concepts and processes, to unpack, explain and organically build them up and to negotiate new, shared understandings' (p. 297).

Furthermore, this current study found that active science learning connected to social contexts was increasingly possible with the use of interactive whiteboard technology. The technology enabled the development of creative science teaching resources that linked directly to internet sites and on-line activities. It enabled fluid access to online real life science contexts which could be annotated at the board with the interactive tools. Consistent with Hennessy *et al.* (2007), this study also found that the IWB created a fluid space where interactive communication allowed the teacher and students to explore science ideas together, pose questions and reconcile scientific and informal ideas. Abstract science concepts could be modeled on the IWB and students were able to demonstrate their scientific knowledge more readily while receiving feedback from interactive activities and their peers.

The following IWB examples represent a snap shot of the range of activities trialed in the pre-service teachers' science workshops. The activities or tasks represent parts that built towards the achievement of learning outcomes in any one workshop. The aim was to engage students and provide opportunities for construction of scientific understandings. The assumption was that to be effective primary science teachers the students needed to develop their scientific literacy. They would develop a general, broad and useful understanding of science that contributed to their competence and disposition to use science to meet the personal and social demands of their life at home, at work and in the community (Murcia, 2007). That is, with an understanding of key enduring science concepts and the investigative and social aspects of working scientifically they would have the ability to:

- *Use science as a tool for inquiry or discovery;*
- *Use science for learning, informing or contributing to problem solving; and,*
- *Critically reflect on the use or role of science in context.*

Generally, the IWB was used in a teacher-directed way to open a workshop in order to engage and motivate the students, provide an opportunity for students to demonstrate their current science understandings and for establishing the objectives and instructions needed for following activities and tasks. The multiple small group tasks in the workshop included hands-on experiments, minds-on discussion questions and interactive experiences at the board. Tasks were designed to connect with familiar knowledge and every day experiences but challenge students to extend their thinking and understanding of key scientific concepts and processes.

1. Visually appealing interactive displays

Pictures, diagrams and photos were imported or captured using the interactive software camera tool and presented with text in the IWB software 'working space' documents called notepads. Microsoft clip art, digital photos and images from the interactive softwares Gallery were easily imported into workshop notepads. Visually appealing displays were created that could be edited, moved or annotated at the board.

Figures were imported from the internet so students could work with data from current and relevant science contexts. The interactive tools allowed emphasis to be given to point, trend and theme analysis as graphs were annotated during discussion. In addition, video clips of moving objects such as a roller coaster were linked to the notepad insuring smooth transition between mediums. The video clips could be stopped at key points and then annotated to highlight relevant concepts such as kinetic and potential energy in the case of the roller coaster.

2. Online information

A range of online learning resources were also accessed via links embedded in the interactive notepads. The websites used in the initial trial provided current information about socially relevant contexts in which scientific knowledge assisted in making sense of the information presented. For example, the website *Information for Action: Water pollution* at http://www.information.org/cgibin/gPage.pl?menu=menua.txt&main=waterpol_gen.txt&s=Water%20sewage. Sites such as this allowed students to access information as questions or uncertainties arose in their learning. In this example, the case of water pollution was a relevant and meaningful context for drawing out and illustrating key science concepts such as pure substances, mixtures, elements and compounds. The IWB tools allowed interaction with the displayed information. Key words were highlighted or underlined and notes or questions were written over the internet site. The camera tool enabled the site and annotations to be captured and saved to the computer. The discussion of the water pollution site then led students to discuss and debate the question of what's in a bottle of 'pure mountain spring' drinking water. Science's role in informed consumerism was then considered in relation to on-line sites which advertised bottled drinking water.

3. Science in the news

During weekly workshops reports of science in the news were viewed as a concrete representation of what was current and relevant to the students' lives and communities. A range of daily news resources were accessed such as:

- Australian Broadcasting Commission (ABC) site, *News in Science* at http://www.abc.net.au/science/news/,
- Australian Academy of Science site, *Nova: Science in the News* at http://www.science.org.au/nova/,

- The Australian newspaper online at http://www.theaustralian.news.com.au/science
- The Society for Science and the Public online US magazine *Science News* special section, *Science News for Kids* at http://www.sciencenews.org/view/interest/id/3/topic/Science_News_For_Kids
- The Royal Society, which is the national academy of science of the UK and the Commonwealth, *Science in the News* at http://royalsociety.org/news.asp?id=54

The editing function on the IWB allowed science terms, concepts and procedures to be highlighted in the news reports. This assisted students to focus on the science issues relevant to the social context and to participate in discussion. Clarification of key science concepts and procedures occurred in this process. This strategy aimed to highlight to students the relevance of science to their lives and its importance in making informed decisions.

4. Science in popular culture

Virtual science demonstrations were also found online and linked into interactive notepads for efficient and timely transitions in the workshops. Some of the most engaging and entertaining were found on *Youtube*. For example, the *Alkali Metal* clip at http://www.youtube.com/watch?v=cqeVEFFzz7E contained entertaining commentary and highly explosive reactions of alkali metals with water. Students would never experience some of these reactions in a classroom due to safety risks. Interestingly, the video not only prompted discussion on safety but also gender stereotypes in science. Students considered who was doing the experiments and who was assisting and the image each portrayed. In addition, students experienced the intersection of science with entertainment through the clip *People run on a pool of Oobleck*, at http://www.youtube.com/watch?v=yH1AcASsf6U.

This proved to be far more humorous and engaging than the small tubs of Oobleck (corn flour and water) investigated in the hands on component of the workshop. The IWB enabled a direct link to the online sites and reduced the risk of being directed to inappropriate sites from a search engine.

5. Interactive on-line activities

A range of online learning resources were also considered for their potential to support the students' learning. Interactive sites were found to be the most effective in engaging the students. Students were encouraged to work in small groups at the board and clarify their learning as they engaged with the resources. The large, hands on nature of the board allowed students to experience kinaesthetic learning. For example, the *Interactive Library: Explain it with molecules* site contains 3D interactive models of water, ice, methane, carbon monoxide, graphite, diamond, salt, soap and DNA on line at http://www.edinformatics.com/interactive_molecules/water.htm

Students rotated the virtual models and experienced their dimensionality while reading and talking about the surrounding descriptive text. Students also engaged with chemical reactions and ionic bonding through interactive activities that provide feedback on their actions and answers. Ionic bonding was observed and conducted through the interactive activity available at http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/flashfiles/reaction/bonding1.html.

This activity highlighted the bonding between metals and non-metals and their positions on the periodic table. Students also balanced chemical equations through the fun-based-learning site at http://funbasedlearning.com/chemistry/chembalancer/ques1.htm.

The interactivity of the sites kept students active in the learning and encouraged group discussion and collaboration with the tasks. The students were clearly motivated and enjoyed the 'game' aspect of the tasks. This was particularly evident when learning key ideas in energy through the *Energy Millionaire Game* at http://www.quia.com/rr/29588.html.

The Learning Federation's Learning Objects and Digital Resources, managed by the Australian Curriculum Corporation were also found to contain a range of useful materials well suited to use on the interactive whiteboard. The Learning Object Catalogues in science are on line at http://www.thelearningfederation.edu.au/for_teachers/catalogues/catalogues.html.

After critically reviewing online materials available at no cost the resources described above were found useful, however, many others had major limitations including inappropriate pedagogy and poor instructions.

6. Constructed interactive resources

At times students' learning needs were better meet by developing original interactive activities with the IWB software tools and simple interactive techniques. Creating original resources allowed the learning experience to be customised to the specific needs of the students. Experience showed that time spent creating an original interactive resources could be time saved trying to find appropriate online materials. The student teachers engaged positively with constructed interactive activities, in particular the modelling and recording of sugar dissolving (Figure 1). In this example, students worked in groups on the IWB and discussed the effect of heat on the dissolving of sugar at a particle level while physically moving the particles to model their ideas. The record function on the IWB allowed both their voices and actions to be recorded. The recordings saved to the computer, allowed the students to review the task and for their understandings to be assessed. This was a powerful tool for formative assessment as it highlighted misconceptions held by some students and also provided learning and teaching opportunities.

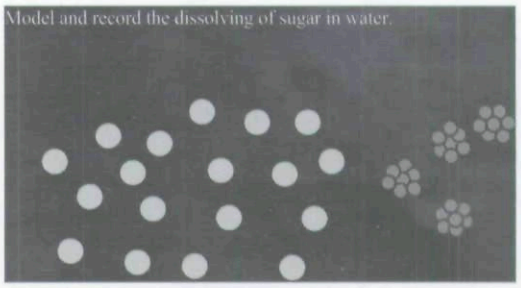

Figure 1. ***Dissolving sugar***

7. Students creating interactive resources

Deeper levels of interactivity were observed when students were required to create and explain their own interactive resources. They were observed, discussing their science conceptions, challenging misconceptions, debating accepted scientific views and negotiating content to be included. For example, the pre-service teachers were asked to construct a concept cartoon that illustrated their understanding of what makes it rain (Figure 2). They worked in small groups and negotiated the key ideas to be presented. Various ideas were tried out on the IWB, some moved while others were edited or erased. The pre-service teachers reviewed their concept cartoons and evaluated its relative merits for use in their future classrooms for eliciting children's understandings. Interactive links to exploratory text and music were later included.

Hennessy *et al.* (2007) suggested the basic tenets of deeper interactivity were 'support for shared cognition, especially articulation, collective evaluation and re-working of pupils own ideas and construction of new knowledge' (p. 298). These characteristics of deep interactivity were evident as students worked collaboratively on the design of their concept cartoon and negotiated its content. Deep interactivity was evident in the students' conversations

and manipulations with the materials on the IWB. The activity also resulted in self assessment and peer feedback on conceptual understandings of evaporation, condensation and precipitation.

Figure 2. *What makes it rain?*

What has been learned from experience?

The strategies described in this paper for using an interactive whiteboard represent parts of the holistic approach required to develop students' scientific literacy. They provided a context for considering the impact of interactive whiteboard technology on students' science learning and should promote reflection on effective interactive pedagogy. Questions emerging out of this experience with using the IWB in science workshops are used to drive the following discussion.

1. Does the IWB improve students' attainment of science outcomes?

The teaching benefits emerging out of IWB research include efficiency, versatility, multimodal presentation and interactivity (Smith, Higgins, Wall & Miller, 2005). Furthermore, Becta (2007) in their report titled Evaluation of the Primary Schools Whiteboard Expansion Project (UK) stated finding evidence of increased student attainment as a result of being taught science with an interactive whiteboard. For example, data from the UK national tests, key stage 1, showed that when students learned science with an IWB,

> *Girls of all attainment levels will make better progress with increased access. There are indications that this positive experience may be shared by average and high-attaining boys but we found inconsistent results for low-attaining boys (p. 5).*

The attainment gains on national tests shown by the UK sample of primary school children appeared to be related to the embedding of effective IWB pedagogy into teachers' daily practice. 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 uses of its facilities (p. 3)*

Kennewell& Beauchamp (2007) argue that it is less clear that the reported advantages in using an IWB are being transformed into benefits for learning. They stated that the 'effect of ICT on learners' attainment depends crucially on the teacher, the pedagogical approach adopted, the ICT resources employed and the learning objectives intended' (p. 227). This would suggest the IWB can only make a difference to students' attainment of learning outcomes when it is integrated with effective science teaching and learning practises. Effective science teaching requires students to be actively engaged, constructing understandings and participating in inquiry learning focused on outcomes that contribute to scientific literacy. Consequently it is important for science teachers to critically reflect on the manner in which the IWB is incorporated into classroom practice.

2. Are the students at the centre of the learning?

Hennessy *et al.* (2007) suggested that traditionally whole class science instruction with technology had largely been restricted to computer demonstrations with little interaction from students. Similarly, when the teacher is the only operator of the IWB the result can be a 'stand and deliver' approach to teaching which, may offer little more than the traditional computer demonstration. Research and classroom experience show that the IWB can increase the pace and appeal of a lesson but can also create a focus on the teacher and board rather than students' learning. Interactive techniques can only be effective when extended into interactive pedagogy that places students at the centre of the teaching and learning experience.

Focus groups from Hennessy *et al*'s (2007) study stressed the importance of the hands-on and student-centred nature of IWB practice. The teachers and students from that study unanimously agreed that 'active physical manipulation of objects by pupils on the IWB was beneficial in terms of learning and motivation—*there's something about touching a screen that really excites them*' (p. 289). It was also evident in the current study that interactive pedagogy surrounding the use of an IWB could create a community of learners in which students not only watch presentations on the board but also physically interact and mentally engage. Providing self-paced small group activities on the IWB increased this group of students' independence from the workshop teacher and required them to display greater self direction and engagement with the learning process. Hennessy *et al.*, (2007) also noted the importance of shared responsibility for IWB activity and learning. They stated, 'An important aspect of knowledge building was teachers' creation of opportunities for sharing with pupils the responsibility for learning and its application, furthered their participation' (p. 296).

3. Is the board used interactively?

The IWB clearly acts as a convergence tool for multiple types of media and the examples of IWB activities discussed here suggest strategies for interacting with and annotating these mediums. However, the capabilities of the board can be under-utilized if it is solely used as a display surface for a data projector. Consideration should be given to using manipulations reported by Miller *et al.* (2004) that facilitate interactivity between teacher, material and students. They listed these as drag and drop; hide and reveal; colour, shading and highlighting; matching equivalent terms; movement or animation and immediate feedback. These commonly used techniques should be explored and adapted so they can be used effectively in science teaching and learning.

4. Does the interactive whiteboard complement hands-on and minds-on activities occurring in the lesson?

The intention was not for the IWB to replace hands-on and minds-on activities in the workshop but rather to complement and extend each learning experience. The interactive activities were integrated and consistent with the conceptual and procedural knowledge development occurring in workshops. Importantly, integrated through the interactive activities described in this paper were higher order questions and student led discussions. Questioning was the means for focussing students' attention, provoking action and for making connections.

Giving consideration to the type of questions used with the IWB was considered important as more recent research suggests there is a possible risk that student think time can be reduced due to the quick lesson pace possible with the technology. Hennessey *et al.* (2007) stated,

> *The ever present concern to maintain lesson pace means that ironically IWB use may afford even less thinking time and opportunity for pupil input than other forms of educational technology (p. 285).*

In light of this experience the role of questioning in effective IWB use in science education is an area worthy of future research. Furthermore, Higgins,

Beachamp and Miller (2007) in their review of the literature on interactive whiteboards identified research evidence showing that 'interactivity is most effectively sustained through effective questioning as well as a wider range of activity' (p. 216).

Conclusion

The integration of IWB technology with pre-service teachers' science workshops required ongoing critical reflection on the interactive tools, students learning needs and effective science pedagogy for developing scientific literacy. The IWB pedagogy described in this paper evolved out of existing practice but also required a willingness to learn new skills, break with habit and think creatively. Producing new interactive notepads each week generated a reflective cycle of planning, acting, recording and reflecting. It was a creative cycle that both drew on and challenged existing practice. Ultimately it was a rewarding experience which received positive feedback from students who consistently attended all workshops. Reflecting on the experience in relation to the IWB research literature highlighted that the answer to engaging students and facilitating their development of scientific literacy was not simply in the technology but in the way it could enhance and extend effective pedagogy. Higgins *et al.* (2007) shared this view; 'good teaching remains good teaching with or without the technology; the technology might enhance the pedagogy only if the teachers and pupils engaged with it and understood its potential in such a way that the technology is not seen as an end in itself but as another pedagogical means to achieve teaching and learning goals' (p.217). Specifically, by acting as a port for a range of information and communication technologies the IWB enabled real life contexts to drive student centred teaching and learning and as such provided opportunities for the development of scientific literacy.

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