IADIS International Journal on Computer Science and Information Systems
Vol. 3, No. 2, pp. 78-94
ISSN: 1646-3692

AN INVESTIGATION INTO THE USE OF INTERACTIVE WHITEBOARDS IN SOUTH AFRICAN SCHOOLS

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ABSTRACT

Across the world computers, and at an increasing rate interactive whiteboards (IWBs), are being deployed to schools as tools for teaching and learning, despite inconclusive evidence regarding their benefits to these environments (Cuban, 2001). The paper describes two case studies as part of a feasibility study performed on behalf of the Eastern Cape Department of Education (ECDoE) to investigate the benefits and drawbacks to the use of interactive whiteboards in South African schools. By examining related work and our own experiences, it identifies seven criteria for the successful integration of interactive whiteboards into teaching environments. By carefully examining each criterion individually, across two schools, the paper illustrates that unless teachers change the way they view, resource and teach classes, interactive whiteboards cannot be successfully integrated into South African schools.

KEYWORDS

Human Computer Interaction, Education, Interactive Whiteboards, User Study.

1. INTRODUCTION

Worldwide Information Communication Technologies (ICTs) are being promoted in education by governments and corporate institutions, based on what Clegg, Hudson and Steel believe to be the myths of "the irresistible power of globalization [and] the determining effect of (neutral) technology" (2003, p39). ICTs are being adopted in education, to a greater or lesser extent, despite the lack of conclusive research in higher education (Noble 2002) or in schools (Cuban 2001). Similar criticism can be levelled at the introduction of interactive whiteboard (IWB) technologies in schools where they are being deployed in spite of little research

informing good practice (Armstrong, Barnes et al. 2005) and where "available academic literature is limited and emerging only slowly" (Smith, Higgins et al. 2005, p91).

There are two notable differences between our study and other studies that have taken place on the integration of IWBs in classrooms around the world: our study is a feasibility study undertaken before instead of after a large scale roll-out such as that undertaken by InterActive Education (Sutherland, Armstrong et al. 2004); and our study takes place in a developing country where access to ICT resources in particular is very scarce. We expect the latter factor to play a large part in the outcome of the study, as the current ICT exposure in South African schools differs so drastically from the learning environments in developed countries.

An IWB system consists of a computer that is linked to a projector. The image from the computer screen is projected onto a surface that is known as an IWB. This functionality can be implemented using two different techniques: a "smart" or "intelligent" board or a "smart" or "intelligent" pen. With the "smart" board technique, the projection surface itself calculates the position of input, whether by using a touch sensitive surface, or electro-magnetic field sensing. A "smart" pen however can be used to augment any flat surface. The "smart" pen technique consists of two pieces of hardware: a receiver that is placed on the edge of the flat surface, and a radio-wave emitting pen. When the pen is pressed on a hard surface, it emits a radio-wave which is used to determine the pen input position with respect to the receiver. A specific benefit of "smart" pen IWBs is the portability. Regardless of the technique used, input on IWBs is transformed into a mouse event and sent to the operating system to process. The research contained in this report is performed using a "smart" pen IWB: an eBeam Interactive Whiteboard Technology (eBeam) (Luidia Systems 2007). Consider the scenario where an IWB is fitted into a senior primary classroom. The teacher, who is confident in the use of ICTs in general, but also in the use of this particular technology, uses it as one of the many tools at her disposal (as opposed to the only tool) to suit the particular curriculum needs. Together with an internet connection, the teacher is able to draw from numerous multimedia sources to prepare stimulating lessons for her class. When presenting the lesson, she encourages her students to participate, firstly through her tailor-made content, but also by facilitating information exchange between the participants in the classroom. The IWB itself is never the focus of the lesson, but it is seamlessly integrated into the learning environment in such a way that it supports the achievement of the intended learning outcomes. If a technical problem does occur with the IWB, the teacher knows that she can call a support-line for immediate assistance with the hardware. This knowledge gives her the confidence to use the hardware daily in her class.

Aware of some of the on-going debates about the potential value of IWBs in schools, the Eastern Cape Department of Education (ECDoE) requested a team of researchers in the Computer Science and Education Departments at Rhodes University to undertake one of a number of feasibility studies to investigate teachers and learners' perceptions of the potential benefits and drawbacks of using IWBs – specifically the eBeam technology – in schools in order to encourage evidence-based policy (Pawson 2004) and evidence-based practice (Cordingley 2004).

The remainder of this paper can be separated into two primary sections. The first section discusses some background literature focusing on the findings of other similar studies and describes our case study, discussing our research question, describing the sites and participants involved in the study, and our methodology. It then goes on to describe two of the cases we observed, one in a former House of Representatives school and one in a former Department of

Education and Training school. The second section discusses our observations and relates it to existing work in the field.

2. LITERATURE REVIEW

In developed countries governments and individual schools have tended to make extensive investments in IWB technologies for education purposes. For instance, the United Kingdom (UK) government has invested substantial amounts of money into IWBs in the belief that their use in education would raise attainment levels amongst school-going learners (Hall & Higgins 2005). The bulk of IWB studies have until now tended to take place within developed countries, focusing on different aspects such as use of IWBs within a specific subject or the perspectives of teachers and learners on the use of IWBs in the classroom (Loveless 2003; Hall & Higgins 2005; John 2005).

As mentioned in the introduction to this paper, the bulk of the research that has been undertaken in this field is based on the use of "smart" boards as opposed to "smart" pens. The most common technical problems experienced by teachers and learners in using these IWBs are: a lack of training time to practice using the new technologies; issues with screen placement; infrastructural problems; calibration issues; shadowing problems; and access to IWBs. The most frequently discussed issue with the use of "smart" boards is a lack of training and / or time to practice using the new technologies (Loveless 2003; Armstrong, Barnes et al. 2005; John 2005; Smith, Hardman et al. 2006). Regardless of the technology being utilized, where a teacher does not feel confident with the technology, this will have a negative effect on the teaching and learning environment. Screen placement becomes an important issue, particularly when boards are permanently fixed in place, as is usual with "smart" boards (Smith, Higgins et al. 2005). If the board is too high on the wall some functions may be inaccessible to teachers or younger (shorter) learners (Levy 2002). On the other hand, if the board is too low it may be difficult for learners at the back of the classroom to see, and so prove difficult to operate (Canterbury Christ Church University College 2003). Related to this is the size of the screen, which is also a contributory factor affecting the visibility of screen content, particularly when the screen is too small (Damcott, Landato et al. 2002). Two important infrastructural issues were raised in relation to the placement of IWBs in classrooms: window awnings and coverings must be considered so that the screen is visible even when the sun shines directly on it (Levy 2002); and, secondly, the multitude of cables required for IWBs must be secured safely and unobtrusively (Bell 2001; Smith 2001). If the cables are pulled accidentally and the screen is moved, the projected image can become misaligned to the physical board, requiring the calibration process to be performed again. Although this is a simple task, it becomes a major inconvenience if it has to be repeated frequently (Smith 2001). A more mundane issue is that teachers and learners must learn to stand to the side of the IWB instead of in front of it, so as not to cast a shadow over the projected image (Bell 2001). Finally, because the IWB is often a fixed resource, usually available in a limited number of venues, it will prove impossible for all teachers to have access on demand (Smith, Higgins et al. 2005). Access must be timetabled, and teachers cannot have access to the resource as and when they want it. Watson (2001) states that the question of how and where ICTs are installed is usually answered on the basis of technical specifications rather than educational needs, with questions such as ease of installation or maintenance proving

decisive. Teachers then have to weigh up the benefits of having access to the resource (including the associated operating costs) against the disruption caused to learners by a shift in venue (Watson 2001).

In previous research studies teachers have been reported as noting the efficiency, flexibility, versatility of an IWB and the opportunities to access multimedia content, as well as their ability to manage the class more easily while using an IWB (Glover & Miller 2001). Teachers viewed the efficiency of an IWB as a major advantage, referring to the ability to seamlessly access one resource after another when using the IWB (Glover & Miller 2001). A related benefit was the flexibility and versatility of the IWB as a teaching tool to allow teachers to support multiple needs within one lesson (Miller & Glover 2002). Another frequently reported benefit was the opportunity for teachers to draw from countless multimedia sources (Glover & Miller 2001; Levy 2002). Finally, IWBs are reported to afford teachers the opportunity to face the class whilst teaching (Smith 2001; Wood 2002) allowing teachers to maintain control and eye-contact with the class.

Although teachers have noted a number of benefits of IWBs in previous research studies this does not necessarily result in easy integration of technology into teaching and learning. John (2005) argues that teachers integrate ICTs into their teaching and learning based on competence, subject tradition, resource provision and technological and pedagogical support. Watson (2001) points out that teachers are at the heart of ICT adoption and pedagogy change, but in order for them to change they need to understand the technology and those developing the technology need to understand the teacher. Watson suggests that if the focus remains on teaching and learning and not only on technology teachers might then be more willing to use technology. Examples of teachers who have successfully integrated technology into teaching and learning are those teachers who can clearly relate the use of technology to their pedagogic strategies for their subjects (Watson 2001). In addition there have been numerous studies that have highlighted the need for time for teachers to experiment, explore and study new technologies as a critical success factor (Watson 2001; Beauchamp 2004; Armstrong, Barnes et al. 2005; John 2005).

Beauchamp (2004) describes five categories of IWB use and integration into which teachers can be characterised; the categories outline the transition from a beginner to a 'synergistic' user of the IWB. These categories are: black/whiteboard substitute; apprentice user; initiate user; advanced user; and synergistic user. Training and experience will help the teacher build confidence and allow them to progress towards a synergistic user (Beauchamp 2004).

3. CASE STUDY

While framed as a feasibility study for the ECDoE, the research can be regarded as a case study. Robson defines case study methodology as ‘a strategy for doing research which involves an empirical investigation of a particular contemporary phenomenon in its real life context using multiple sources of evidence’ (1993, p52). Case study research has the drawback of not being easily generalised, but if it is ‘contextualised and carefully described […] then others can consider its usefulness in other contexts and examples’ (Wisker 2001, p191). In fact social realist research explicitly holds that:

> No individual-level intervention works for everyone. No institution-level intervention works everywhere. The net effect of any particular programme is thus made up of the balance of successes and failures of individual subjects and locations. What this points to is the need for a careful look at subject and contextual difference in terms of who succeeds and who fails within any programme (Pawson 2004, p30-31).

Our reporting therefore does not claim to generalise, but does attempt to highlight issues that have – either positively or negatively – influenced teachers' or learners' use of IWBs. As Pawson explains: 'At the extreme, we can still learn from a negative net effect of a single evaluation study, since the application of an initiative to the wrong subjects and in the wrong circumstances can leave behind vital clues about what might be the right combination' (2004, p31).

The main research question that the team sought to address was how and why do IWBs using "intelligent" or "smart" pens enable or constrain teaching and learning in South African primary and secondary schools. In order to answer the main question, the following five subsidiary questions were posed:

- What experience and ability do teachers have in using ICTs and IWBs in particular?
- What benefits and drawbacks do teachers perceive when using a "smart" pen in their teaching?
- What preparation do teachers need to undertake to successfully use a "smart" pen in their teaching?
- What benefits and drawbacks do learners perceive when using a "smart" pen in the classroom?
- What changes do learners need to make when using a "smart" pen in the classroom?

This section provides a detailed description of the case study. It begins by describing the three schools involved in the study, along with an overview of the selection criteria for school participation. Next it identifies and justifies the methodology we chose. Finally it describes in detail two of the five cases that were examined throughout the duration of the case study.

3.1 Sites and Participants

One of the features of apartheid was that South African schools were separated (and funded) according to race (National Education Policy Investigation 1992; Howie, Muller et al. 2005). When South Africa became a democratic nation these state school classifications fell away. The disparities of the past however, still have a large affect on these schools today: former Department of Education and Training schools (black schools) tend to be more disadvantaged than former House of Assembly schools (white schools). Somewhere in the middle lie Former House of Representatives schools (coloured schools). For this reason we retain the former terms in order to differentiate between the historically poorly resourced FDET schools and the well-resourced FHOA schools (Howie, Muller et al. 2005).

In order to undertake the investigation, the ECDoE supplied eBeam projection systems, for two secondary schools and one primary school in Grahamstown. As the ECDoE was contemplating purchasing only one eBeam per school, we needed to explore not only how teachers could use IWBs in their individual classrooms, but what logistical issues might enable or constrain the optimal use of eBeam technology across at least three classrooms. The study was conducted at three schools: one primary school and two secondary schools. To preserve anonymity the names of the schools have been withheld, and codes assigned instead

(see Table 1). As shown in Table 1, all three schools are considered previously disadvantaged schools. These schools were chosen because the ECDoE was interested in the perceived benefits and drawbacks of the eBeam technology in previously disadvantaged schools and because these schools already had basic ICT infrastructure in place, together with computer-literate teaching staff who were willing to participate in the study.

Table 1. School categories and codes

School	School category	School code	Teacher code
Primary school 1	FHOR	School 1	Teacher A
Secondary school 1	FHOR	School 2	Teacher B
Secondary school 2	FDET	School 3	Teacher C Teacher D Teacher E

One teacher participated from the primary school and one teacher participated from one of the secondary schools (School 2). In the other secondary school (School 3), three teachers were involved in order to enable an investigation into the advantages and disadvantages of the mobility of the eBeam unit.

Additional factors which contributed to the choice of schools in the study were as a result of criteria that emerged from the literature and from other studies that were recently conducted in the same area (Maholwana-Sotashe & Hodgkinson-Williams 2005; Mbane & Hodgkinson-Williams 2005; Brandt 2006). The Grahamstown area was chosen as it is close to Rhodes University where the research team is based, and because recent studies by the research team has enabled us to establish the necessary relationships with the school principals and teachers to be able to conduct a study of this nature. This type of observational case study requires a deep level of trust as teachers open their classrooms to scrutiny from outside parties. It is therefore essential that the teachers trust the research process and the researchers implicitly. Moreover, Brandt's (2006) studies helped identify what computer infrastructure Grahamstown schools have in place. The researchers were therefore able to select the schools that have the necessary hardware, software and connectivity that this project requires. In addition, it was critical that the teachers involved were willing to participate and able to use the technology. The latter presupposes some formal or informal experience with using computers in the classroom as well as a willingness to adapt their lessons and pedagogical strategies to best suit the affordances or possibilities of the technology. Brandt (2006) and Maholwana-Sotashe and Hodgkinson-William's (2005) studies enabled the researchers to identify suitable teachers, who had the necessary prior ICT experience and had indicated a willingness to be involved in a research study

Although a total of five cases were observed, this paper only reports on two of them. Previous papers have been derived from the same research, examining: the potential benefits and drawbacks of IWBs compared to laptops and data projectors (Slay, Siebörger et al. 2008a); the pedagogical practices of the teachers when using IWBs (Slay, Siebörger et al. 2007); the use of IWBS to support creation and capture of knowledge (Slay, Siebörger et al. 2008b); and the the perceived benefits and drawbacks by the teachers and learners in using IWBs in the classroom (Siebörger, Slay et al. 2009). As will be shown in Section 4, subject areas play a large part in the ability for IWBs to be integrated into classrooms (Andrews 2000; John & La Velle 2004), so throughout this paper we have aimed to showcase those with the most in common. Teachers C and E taught Business Economics and Mathematics

respectively, while Teachers A, B and D taught English. Of the three English teachers, Teachers A and D were both teaching sentence construction, as opposed to Teacher B who was teaching sonnets, and so were chosen for the study. Teachers A and D are discussed in greater detail in Sections 3.3 and 3.4 respectively.

3.2 Methodology

As our guiding principle in this research we followed Pawson and Tilley's realist maxim of research design which is to 'produce more detailed answers to the question of why a program works for whom and in what circumstances' (Pawson & Tilley 1997). Our research design decisions included formulating research questions, selecting the sites for piloting the IWBs, identifying the teachers with whom we would work, determining the research methods we would use to elicit responses from the participants, and techniques for capturing and analysing data. We also identified from whom permission needed to be sought, and devised letters of consent for each party.

The duration of the study was initially set at six months by the ECDoE as they were interested in rolling out interactive whiteboard equipment to schools in 2007, but wanted to know how effective it would be before making such a large monetary investment. One of the other feasibility studies investigated the use of a permanently mounted interactive whiteboard, whereas our study investigated the more portable and cheaper eBeam technology that makes use of a radio transmitter attached to an ordinary non-interactive whiteboard. Due to delays in the arrival of the eBeam equipment and the installation of the whiteboards in the schools, a month was forfeited, so the study eventually commenced in August 2006 and an initial data report was submitted to the ECDoE in mid-December 2006.

Prior to the study, permission was granted by the local District Office and subsequently each principal, teacher and learner signed a consent form. To ensure that teachers were provided with adequate training, four 2-hour training sessions were held. The first session was held at a local independent school that had recently purchased an IWB and a teacher, familiar with IWBs, demonstrated its use to the group of teachers, their school principals and researchers. We assumed that it would be useful for teachers to observe how IWBs are used in a classroom situation. In subsequent training sessions, teachers: learned how to assemble, calibrate, and disassemble equipment; were given basic instructions on presenting lessons with the hardware; and presented a lesson they had prepared in front of the other participants and researchers; respectively. Throughout the training, researchers observed teachers' ICT skills and attempted to provide additional support to those who were less familiar with ICTs.

After the training, teachers were interviewed separately in order to determine their ICT skills, their typical use of ICTs in the classroom, and how they thought they would use an IWB in *their* teaching environment. The average duration of each interview was 15-20 minutes, and followed a semi-structured interview schedule with a series of key questions that commenced with some reasonably non-emotive questions (to put the interviewees at ease) and then progressed to the more theory-laden questions. "Theory-laden" refers here to our theories as researchers of what we deemed to be, through our reading of the literature and through our own reflections, the potential benefits and drawbacks of using IWB technologies.

Over the four month period, each teacher was visited at least three times, with each visit being observed by (on all but two occasions) two researchers. In these two cases, only one researcher was available to undertake the observation. All classroom visits were scheduled to

the convenience of the teacher. Observation sheets were adapted from a previous study by Orlando (2005) in an attempt to standardize the recording of the behaviour observed in the classroom and to foreground the key issues. The observation sheet included a range of data recording techniques including the drawing of the layout of the classroom, rubrics to judge the use of software, Likert scale type questions and narrative comments. During the observations, photographs were taken in order to capture some of the visible constraints that both teachers and learners had to overcome in using the technology. Permission was sought for each photograph used in the presentation of the data.

On completion of their last observation, each teacher was again interviewed to elicit their opinion on their experiences with the IWB in their classroom. The average duration of each interview was again 15-20 minutes and followed a similar process to that outlined in the description of the pre-observation interviews. As we were also interested in the learners' perceptions, 10 learners from one of each teacher's classes were selected to participate in post-observation focus group interviews. The learners were selected according to their availability and willingness to participate in the focus group (Cohen, Manion et al. 2000). We chose the focus group approach to encourage discussion amongst the learners as some of them may have felt to shy to comment on a one-to-one basis.

In an attempt to triangulate the data, throughout the whole user study we employed three of the four types of triangulation put forward by Denzin (1978), namely *methodological, data* and *investigator triangulation.* We used multiple methods to study a single problem (methodological triangulation); we elicited comments from various sources of data which included the teachers and the learners (data triangulation) and included the observations of three researchers (investigator triangulation). Throughout this paper we have ensured methodological triangulation by the use of photographs, observation sheets and transcripts of pre and post interviews. We have also ensured data and investigator triangulation by using recorded comments by teachers and multiple observers.

3.3 Primary School 1 (School 1), Teacher A – Grade 6.

This primary school teaches learners from Grade R – 7 and is a former House of Representative school. The medium of instruction at this school is English, and it was originally started by Anglican nuns in 1854. The school premises are very small, with only four classrooms in the original wooden-floored building. However the school rents a hall across the road which can accommodate another two classrooms – separated with "pre fab" walls. The school consists of 230 students, with 9 staff members. It has five working desktop computers and one server, which are networked within the school and connected to the Internet. Four computers are located in classrooms, with the additional computer being used by the administration. Teacher A's classroom contains one Pentium 2 computer that can either boot Windows '98 or can boot as an Edubuntu Linux thin client from their central server. The vice principal of this school was very supportive of our research project, even attending and participating in the training sessions prior to the commencement of the observations.

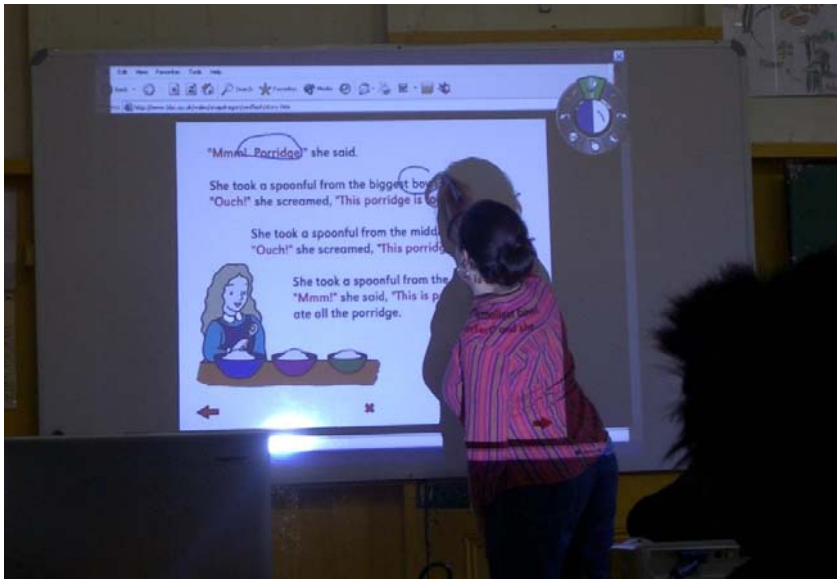

Figure 1. Teacher A with Goldilocks story.

Teacher A is a Grade 5, 6 and 7 English first additional language teacher, who teaches a range of learners who mostly speak English as their second or third language. Although there were 36 learners enrolled in this class, only an average of 29 learners (across all observations) attended the class. Throughout the duration of the study, we observed her Grade 6 class. Some of the learners in her class struggle to read and write in English, often these children arrived in the class unable to do either at all. The average age of the learners is 11 years old, however those learners who are unable to read are sometimes as old as 13. Teacher A has had experience in using ICTs since 1998. She began with a very basic computer literacy course that was run by a local outreach program, Teacher Aid Programme (TAP). Since then she completed her Advanced Certificate in Education in ICT course through Rhodes University (a two year diploma course for in-service teachers).

The sequence of lessons observed at this school was focused on reading a Flash story of Goldilocks and the Three Bears (Figure 1). The interactive story included both voice and video in its presentation. In the first lesson, the teacher and learners read along with the story, with each learner taking a turn at reading a page aloud from the board. They were then given a handout exercise on prepositions and took it in turns to identify the prepositions on each story page. Learners were then given a group exercise to complete on prepositions, and each group got a chance to report back to the class by writing their answers on the board (writing was captured using eBeam). In the second lesson learners revised the Goldilocks story, and then were split into groups to research about endangered bears. Groups took turns using the laptop (with Encarta) and the other computer in the classroom (with Internet connection) to perform their research. While waiting for their turn, learners worked on writing a traditional story. After doing the research, groups presented their work to the rest of the class using the eBeam. In the final lesson, learners again took turns in reading a page aloud from the board. After reading, the learners identified the nouns in each page. Learners were given a group exercise to complete in groups on nouns. After completing the exercise, each group wrote

their answers on the board, while the teacher used the eBeam to capture their answers for revision at a later time (Figure 2).

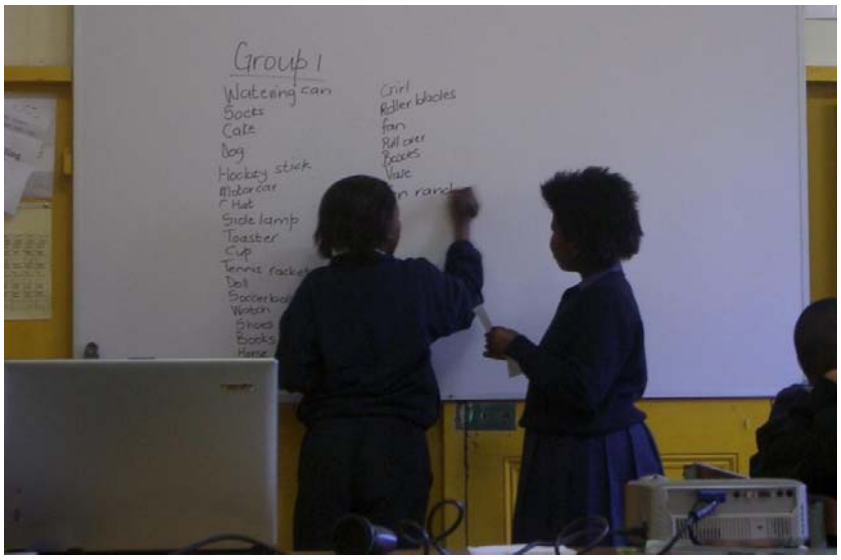

Figure 2. Students writing answers on board.

In the first two lessons, learners were very engaged in the class. In the third lesson however, students were mostly enthusiastic, but several were quite disruptive. This may be due to having outsiders watching the class (the observers), but it also could be due to the fact it was the end of the term. The teacher successfully incorporated the eBeam into her teaching, using it as one component (not the only component) of the lessons. Teacher A's excited attitude towards the use of the IWB seemed contagious, as the learners were all excited to participate and present their work to their peers using the board. Most technical problems that occurred during the study were solved by the teacher or learners themselves, with the researchers having to provide brief assistance once.

3.4. Secondary School 2 (School 3), Teacher D – Grade 9

This is the second of the two high schools that took part in the study. The school is a former Department of Education and Training school which offers Grade 8 to Grade 12. The school consists of 600 learners and has a staff complement of 20 teachers. The school comfortably accommodates one large computer lab. Computers at this school are either old Pentium 1 computers which boot Windows '98 or newer Pentium 4 computers which dual boot Windows XP and Edubuntu Linux. The school has a FreeBSD server which provides file sharing, mail, web space, domain and Internet routing services. The principal of this school was also very supportive of our research project. He was one of the three participants in the user study from this secondary school, and as such he attended and participated in the training sessions and allowed us to observe his classes.

Teacher D is an English, History and Life Orientation teacher. During the course of the study we observed her Grade 9 English class, which consists of learners who are about 15

years old. Her first experience of computers was during her Higher Diploma in Education (HDE) where she received pre-service computer literacy training and again during her B. Ed (Hons) where ICT was one of her electives.

In the first lesson, Teacher D used MS Word to work through examples of concords with the class. She started by opening a blank document and tried writing sentences on the board. As her handwriting was very messy, the handwriting recognition software kept identifying the strokes as the wrong letters. Eventually one of the observers was asked to correct the sentences using the laptop's keyboard. Once sentences were written on the board, students took it in turns to correct the concords. In the second lesson, the teacher took 15 minutes to set up the hardware for the class, even though the laptop and data projector were already connected for her (she used the same classroom as one of the other user study participants). After struggling for a few minutes she realised she had forgotten the eBeam unit itself so asked a student to fetch it, along with one of the other user study participants. When the hardware was finally configured, two learners were dispatched to collect the learners' exercise books that the teacher had also forgotten. While the two learners were away the teacher set up the software required for the lesson. This task took 12 minutes to complete, although it only consisted of double clicking on two icons on the laptop's desktop. When the class finally started, the teacher only had time to go through some sentences on the board. In the last lesson, the teacher decided to use the projector without the eBeam. She used MS Word again to show different road signs. Learners took turns to recognise the signs and call out their meaning. Ten minutes before the end of the class, Teacher D decided to set up and calibrate the eBeam, only to dismiss the class when she had finished the process.

Throughout all observations, Teacher D was very unsure of the technology, and seemed unprepared for the classes. It was curious to note that in the first lesson, Teacher D was very confident and competent at setting up the eBeam hardware. As time progressed however, she seemed to get worse at this task. From a technical perspective, both Teacher D and the learners kept mistakenly holding the button on the pen and engaging the right-click option. The teacher also did not seem to grasp the different modes that the pen could be used in: as a mouse, or as a scribe. Students had immense trouble with the handwriting recognition software, but the teacher seemed not to realise that this could be turned off. As an example, the students seemed to form letters using their own techniques. As the handwriting software works by analysing strokes, it would interpret a circle stroke followed by a vertical line stroke as "O1" as opposed to a lowercase "a", which caused great mirth, but distracted from the focus of the lesson.

4. DISCUSSION

The previous two subsections described two case studies of the five teaching environments that were investigated. These two case studies were chosen, because from the outset, it seemed they would have the most in common. This section describes key criteria for the successful integration of IWBs into learning environments, as described in other ongoing research projects, and shows how our findings are aligned or differ from these points. It aims to show the key factors that caused the vast differences between the observed behaviour in the two classes.

John and La Velle (2004) argue that math and science based subjects have a "greater affinity" with technology than humanities subjects. Andrews (2000, p9) goes further to say that the "humanities based, liberal and book-dominated culture of English … is undoubtedly a factor in the resistance of English teachers to new technologies". In order to support a valid comparison between our two cases, we have analysed two teachers, who were teaching similar subject matter. Throughout our observations Teachers A and D both focused on different aspects of sentence structure: Teacher A was identifying prepositions and nouns, whereas Teacher D was describing concords. For this reason, we can conclude that in our case, differences between the observed teachers' behaviour is not due to the subject matter being taught.

Numerous studies have pointed to giving time for the teachers to experiment, explore and study new technologies as a critical success factor (Watson 2001; Beauchamp 2004; Armstrong, Barnes et al. 2005; John 2005). Within our study, both teachers were provided with a week of training in the use of the IWB in a teaching environment, along with two weeks subsequent to the training to practice with the technology. By design we chose to hold joint training sessions to ensure all teachers were given the same information about the IWBs. The two teachers had the same amount of time to experiment with the IWB prior to using it in their classroom. This time was not monitored however, so we do not know how Teachers A and D made use of the time. We therefore maintain that as teachers were given the same amount of time to experiment, this factor cannot explain the difference between the observed behaviour of Teachers A and D.

In a previous study, Beauchamp (2004) suggested that teachers should be ICT literate before they are expected to integrate IWBs into their classroom. This is an obvious pre-requisite as the IWB can be seen as an extension of a traditional computer. Both teachers have ICT related qualifications, with Teacher D having completed far more formal education than Teacher A. When asked about the ease of use of the IWB, Teacher D replied "*It wasn't difficult at all. You just get used to using it. After two or three days using it, you just know how to use it*". This self-professed ability was not evident however throughout our observations. Even though Teacher D had more qualifications than Teacher A (which included undertaking honours classes in ICT), her computer literacy was not apparent in the lessons that were observed. As Watson (Watson 2001, p255) notes, "knowledge of ICT skills do not mean these skills are always applied". Similarly to teachers involved in other studies (Watson 2001; Beauchamp 2004; Armstrong, Barnes et al. 2005), both Teacher A and Teacher D called for continued teacher training in ICTs in general, but also on the use of IWBs. When Teacher A was asked what she thought was necessary in successfully deploying and integrating IWBs in the classroom she said *"I think ongoing training. For me as well. Because you know, I don't know everything. In all ICT things, because things change all the time"*. As Teachers A and D were both formally trained in computer literacy, we conclude that qualifications in and of themselves are not enough to guarantee computer literate teachers or successful ICT integration.

Related to ICT literacy is access to ICT facilities. As the schools involved in this study were previously disadvantaged, the learners who attend them came from disadvantaged backgrounds. Teacher A explained the circumstances of the learners by saying:

> *TEACHER A: OK, our learners come from very disadvantaged backgrounds, they are basically impoverished. And so on the whole they are not exposed to computers. A small percentage of the learners has ever used a computer so when they come to school its a new thing - and so they love learning about it and they do learn quickly,*

> *but then the hindrance is that you can't send them home to go and do something and there isn't enough time at school to do all the things you want to on the computer. Because at school our longest period is 55 minutes so after teaching and giving them their activity to do there often just isn't enough time for them to all do it if its on the computer.*

As previously mentioned, Teacher A's school has a total of four computers that learners can use, with at most one computer in each classroom. As the classes are quite large, learners spend very little time using the computer. Usually, if Teacher A wishes to show the learners something on the computer, she breaks them into groups of 6 and the whole group uses the computer at once. Teacher D's school on the other hand was equipped with a full computer lab. This lab is a common resource, where teachers can schedule classes in the computer lab when needed. As well as being able to use these computers during their classes, learners can pay R50 (approx $US 7) per year to use the computers and take part in computer literacy courses after hours in a computer club. Both teachers and learners at Teacher D's school therefore appear to have more access to ICT facilities, but this access did not manifest itself as increased skills on the part of either the teacher or the learners in Teacher D's class. We therefore conclude that in our case, access to facilities can not be shown as a cause for the difference in observed behaviours in the two classrooms.

There are two types of support that are identified in related work as being crucial to the successful integration of ICTs into the classroom: administrative support (Watson 2001); and technical support (Watson 2001; Beauchamp 2004; Selwood & Pilkington 2005). Both Teacher A and Teacher D were lucky enough to have very supportive principals and administrators. To show support for Teacher A's involvement in our study, Teacher A's vice principal attended the training sessions to see how this new technology could be used in the classroom. Teacher D also had a very supportive principal who even took part in our study as one of the other teachers from the school. We therefore conclude that in our case, administrative support played no part in explaining the differences in the observed teachers' behaviour.

Most studies into the use of IWBs in classroom environments cite the provision of technical support as an enabling factor for their successful integration (Loveless 2003; Armstrong, Barnes et al. 2005; John 2005; Smith, Higgins et al. 2005). One piece of technical support that was given to the teachers was a step-by-step guide on how to problem solve simple issues that might occur with the setup and configuration of the hardware and software. Teacher A even commented on this during her post-observation interviews saying "*… you can sort-of problem solve when you find things are not working, and you have to think back to 'What did [the researcher] do in the training', and go back to your notes...".* As well as this guide, Teacher D also benefited from informal technical support from the other two teachers in her school that were involved in the study. During our observations of her class, Teacher D called on one of the other teachers to help set up the hardware and software. Both Teachers were also given the opportunity to discuss any technical issues with researchers throughout the duration of the user study. The two teachers both realised and commented on the importance of technical support in their post-observation interviews, calling for ongoing training in ICT skills. As Teacher D received more technical support than Teacher A, we deduce that the simple provision of support is not enough to guarantee a successful integration of ICTs into the classroom.

The final criterion is a change of thinking on the teacher's part on the way classroom activities are resourced and taught (Miller & Glover 2002). In a study into the integration of

IWBs in Wales, Beauchamp (2004) found that although teachers started from the same point with generic ICT skills, he could identify a range of competencies and changes in pedagogic practices over a period of a year. From this he created a scale to delineate the transition from beginner to synergistic use of the IWB: blackboard substitute; apprentice user; initiate user; advanced user; and synergistic user. Beauchamp's findings correlate perfectly with ours, as Teacher A and D started from a similar point, but Teacher A advanced at a faster pace than Teacher D. Using Beauchamp's scale, Teacher D would be classified as a blackboard substitute user, as she uses the IWB primarily for writing and drawing, but towards the end of the study used it to open or save word processing files. Teacher A on the other hand would be categorised as an advanced user, as she had moved "beyond a fascination with technical capabilities, toward the excitement of discovering their impact on teaching and learning" (Beauchamp 2004, p340). We consider this to be the primary difference between the two teachers, and as shown in the Sections 3.3 and 3.4, its affects were far-reaching.

This section has illustrated that the successful use of ICTs in classrooms, and in this case IWBs in particular, depends primarily on the teacher's willingness to adapt their teaching styles to take advantage of the new technology. Teacher A had the same introduction and experience with IWBs, fewer qualifications, fewer facilities, lower learner ICT exposure, similar administrative support, and less on-site technical support than Teacher D, yet she successfully incorporated the use of the IWB into her teaching. We would argue that a willingness to change and adapt teaching practices to incorporate the use of technology is imperative to its adoption. A willingness to change pedagogic styles on the part of the teacher has also been highlighted in past research (Sutherland 2001; Smith, Hardman et al. 2006).

5. CONCLUSION

This paper has described two case studies undertaken by researchers in the Computer Science and Education Departments at Rhodes University on behalf of the Eastern Cape Department of Education to determine how and why IWBs enable or constrain teaching and learning in South African primary and secondary schools. Although the study involved five different classroom environments, this paper has focused on two of the observed classes that from the outset had the most in common.

By referring to related work, we found seven key criteria for the successful integration of IWBs into learning environment: time to experiment with the technology; ICT literacy; access to ICT facilities; exposure to ICT; administrative support; technical support; and a change in pedagogical practice. Although the first six of these factors can have an affect on the ability to successfully integrate IWBs into the classroom, this paper has illustrated that providing them does not guarantee success. In our study Teacher D had every advantage over Teacher A, yet these advantages did not manifest themselves in her teaching. The only criteria that fell in favour of Teacher A was the way she viewed, resourced and taught the classroom activities. We conclude that even in the most difficult teaching and learning environments, it is the teacher's willingness to change that "makes-or-breaks" an ICT deployment in schools.

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