The Introduction of Interactive Whiteboard Technology in the Primary Mathematics Classroom: Three Case Studies

Penelope Serow
University of New England
<pserow2@une.edu.au>

Rosemary Callingham
University of New England
<Rosemary.Callingham@une.edu.au>

Interactive whiteboard (IWB) technology is present in a large number of Australian primary schools. Despite the rapid increase in availability of this technology over the last five years, previous research suggests that the technology is being used for sophisticated transmission style teaching as opposed to constructivist approaches. This paper presents findings of a project which considered the implementation of IWB technology in three Victorian primary mathematics classrooms. The case studies explored the teaching strategies adopted by three teachers as they embarked on the use of IWB technology as an integral component of mathematical activities with the support of professional development.

It is evident that "few studies have been published on the effectiveness of technology within geometry classrooms" (Coffland & Strickland, 2004, p.347). Many classroom teachers confidently use technology as a presentation or display tool, but remain unaware of the potential for Information and Communication Technology (ICT) to promote concept development in the mathematics classroom. This was emphasised by Fitzallen (2005) through the recognition of "a need for teachers to gain an understanding of how Information and Communication Technology (ICT) can be used to extend students' thinking and problem-solving skills, rather than just a publication and research tool" (p. 253).

An Interactive Whiteboard (IWB) is a touch sensitive display board, sensitive to finger or pen-like devices, used in conjunction with a computer and a digital projector. The IWB technology used as a medium in this project was a student pad. The student pad is a portable A4 size template, which is touch-sensitive, to allow students to manipulate the IWB technology from any position in the classroom. Although the number of classrooms in Australia that have IWB technology installed is unknown, there are a large number of primary and secondary schools that have purchased and/or installed the technology and intend using IWBs during mathematics lessons. It is evident that both teachers and students are enthusiastic about using IWB technology in the classroom, but it is not clear if this excitement and enthusiasm is transformed into effective teaching strategies and meaningful mathematical experiences (Tanner & Jones, 2007).

Deaney, Ruthuen, and Henessy (2003) stated that the supply of technology is of limited value without an understanding of "the interactions and processes engendered by using technology in different settings, and how pedagogical strategies to enhance students' learning might be developed effectively through them" (p. 142). This suggestion echoed McGehen and Griffith's (2004) contention that teachers must develop an appreciation of the ways in which technology can enhance and encourage mathematical thinking. It has been claimed, however, that IWB technology can reinforce teacher-centred pedagogy, leading to students becoming passive recipients of information rather than active, engaged learners (Moss et al., 2007).

A number of themes have been identified in relation to students' perceptions of problems when using IWB technology. These included technical problems with the equipment, varied levels of ICT skills of teachers and students, and lack of student access to the IWB technology during the classroom activity. This study found that

> … while the technology is clearly engaging from the students' perspective there is a concern that any gains in this direction will be lost if the technology is not reliable, if teachers are not adequately trained to use it, and perhaps more importantly, if the educational climate militates against increased pupil access to the technology. (Hall & Higgins, 2005, p. 114)

This finding suggested that both teachers and students needed experience in "playing" with new technology, and teachers should have professional development that addresses both skill-based aspects of technology use and effective pedagogical approaches when technology is used. In relation to this issue, Smith, Hardman, and Higgins (2006) stated that "more extensive research needs to be carried out into ways of effectively supporting teachers in their professional development in order to promote more reciprocal forms of teaching to increase the opportunities for extended teacher-pupil interaction" (p. 456).

The study reported in this paper involved three teachers who were implementing IWB technology in their primary classrooms for the first time. They were supported through professional development sessions in which they were introduced to developmental models of learning with a teaching framework provided by the pedagogical phases developed by Dina van Hiele-Geldof. The five teaching phases aim to facilitate the cognitive development of a student through the transition between one level of development and the next. The phases originate from the idea that "help from other people is necessary for so many learning processes" (van Hiele, 1986, p. 181). Learning is deemed a social process and stems from the notion that students find it very difficult to move unassisted from one thought level to the next. This idea, however, is exactly what IWB technology appears to inhibit. The use of van Hiele teaching phases addressed the concern that "teachers often feel reluctant or uncomfortable because their pedagogical knowledge perhaps does not include a framework for conducting technology-based activities in their lessons" (Chua & Wu, 2005, p. 387).

The second framework used in the professional development sessions was the SOLO model. The SOLO model grew from Biggs and Collis' (1982) desire to explore and describe students' understandings in the light of the criticisms of the work of Piaget. Rather than focus on the level of thinking of the student, the emphasis in the SOLO model is on the structure of students' responses. Of particular interest to this study were investigations concerning geometry concepts (e.g., Davey & Pegg, 1992; Olive, 1991; Pegg & Davey, 1998; Serow, 2002, 2006). The framework is composed of two main components, these being: modes of functioning and cycles of developmental levels. Application of the SOLO model was part of the professional development of this project to assist teachers in determining effective teaching practices that could make use of the potential of technological tools within the framework provided by the teaching phases.

The first professional development meeting introduced the teachers to the school pad and its associated software. Teachers were able to use the school pads and to explore the range of possibilities offered. The later professional learning sessions were explicit about linking technology use to concept and cognitive development. Teachers saw use of the IWB technology modelled in presentations, were able to experience using the school pads and to interact with computer programs in ways that promoted developmental ideas.

With this background, the research questions for this study were:

1. In what ways does using IWB technology support students' active involvement in learning mathematics?
2. What issues emerge in introducing school pad technology into primary mathematics classrooms?

Method

The study took place over one school year in 2007. Teachers were supplied with a school pad and undertook to use it in mathematics lessons wherever possible. The particular focus was the space strand of mathematics, because this had been identified as an area of need by the schools involved. Apart from these commitments, no restrictions were placed on teachers as to how they implemented IWB technology within their different contexts.

Sample

The teachers involved came from three different primary schools in Victoria. School A was situated in a suburban area. It had an enrolment of approximately 450 students, of whom more than 80 percent spoke English as a second language. The teacher, Mark, taught a year 6 class. He was an experienced teacher, having taught for about 10 years. The classroom was equipped with an interactive whiteboard, as well as a small school pad supplied through the project. School B was also suburban. It had 600 students, mainly of Anglo-Celtic origins. The teacher, David, taught a year 5 class. He was the least experienced classroom teacher, having come into teaching as a mature-age entrant after a varied career, including some time teaching in the TAFE sector. The school pad supplied by the project was the only access to IWB technology, but he also made use of a computer laboratory. School C was situated in a country town. This school was a small school of approximately 133 students. The teacher, Agnes, was very experienced, having taught for well over 20 years, and she also held a Masters degree. She taught a year 4 class, and the school pad provided the only access to IWB technology in the school.

Data Collection and Analysis

Data were collected from three sources. Classroom visits were made to all three schools, and lessons using the school pads observed. Particular attention was paid to the ways in which the students used the school pad, and the teachers' questioning. Three meetings were held with the teachers. At these meetings, teachers reported their classroom experiences and activities, received training in the use of the school pads and input about developmental approaches to teaching the space strand, with particular reference to the use of IWBs. The final data source was student work samples provided by the teachers or collected during school visits.

A case study approach was taken with each school providing a case (Stake, 1995). In addition, records of the meetings and classroom observation data were analysed qualitatively using a clustering approach (Miles & Huberman, 1994) to identify common themes as well as differences among schools. The work samples were used to triangulate teachers' comments about their students' progress.

Results

The results are presented as three short case studies, followed by an identification of common themes. Each school is discussed separately.

In school A, Mark made less use of the school pad than the large wall-mounted IWB. He used some features of the IWB software effectively to develop students understanding. In particular he used the spotlight or curtain feature to reveal gradually a 2-dimensional shape, providing a virtual equivalent of a well known activity included in the Early Years Numeracy Research Project assessment interview (Clarke et al., 2002). Students were interested and engaged, but they tended to consider single features of a shape rather than integrating these into a deeper understanding of the properties and relationships among properties. Students produced a PowerPoint report about angles, but the focus tended to be a description of single features rather than links to properties of shapes, or angle as a measure of rotation. Mark was also making use of support materials provided electronically by the education system through the Internet, as well as other public Internet sites, including *TeacherTube* (http://www.teachertube.com/). These motivated and interested the students in mathematics.

David, in school B, also made extensive use of technology, including the school pad. He took longer to implement technology use in the classroom saying "I needed to get my head around it first". He also found some difficulty working with the technology until he was able to set up the necessary computer and data projector permanently in his classroom. By third term, however, David had planned and implemented a fully online unit of work around properties of shapes. Students were making extensive use of technology in a number of ways, including exploring shape, creating a PowerPoint and submitting this for assessment electronically through the school intranet. Students were able to act autonomously in their choice of shapes to explore, and it was noticeable than many had chosen relatively unusual shapes, such as nonagons. Use of the school pad appeared to be restricted to individuals taking it in turns to practice using the tool, although David did say that he was using this in other ways in subjects outside mathematics.

The younger students in Agnes' class were also impressively fluent in their use of technology. In this school, as in School B, infrastructure was an issue. Access to data projectors and screens was limited and Agnes had to rely on makeshift arrangements using window blinds to project the image. The focus in this classroom was on group work with several activities all addressing the same general topic of 3D objects and their properties. Agnes had laid down some rules for use of the school pad. Each student had to take a turn so that collaboratively the group created a representation of a 3D object. In the observed lesson, a group was working cooperatively using isomorphic dot "paper" and the school pad to draw a square-based pyramid. This created much discussion among the students in the group about where to draw the lines and whether the representation was accurate. The rest of the class was undertaking a variety of activities, including building with concrete materials, writing about a chosen shape in their mathematics books and using drawing packages on computers to explore 3D shapes. Agnes stated that she felt that the most powerful aspect of the IWB technology was the conversations it created among the students. During the school visits, it appeared that Agnes was using the van Hiele phases of teaching to design her lessons, moving from the students' development of mathematical ideas and informal language, to more formal language to communicate mathematically.

Student work samples were revealing. All teachers expressed the view that their students had been more engaged and motivated by the use of the school pads, and that their learning had benefited. Certainly the students observed were confident and engaged by the technology. Despite the students' fluency in using the technology however, the focus of this use tended to be on presentation rather than the mathematical ideas.

In some instances, the level of thinking displayed was somewhat disappointing. For example, a year 5 student wrote "For my shape I chose a triangle. A triangle has 3 corners and three sides. The triangle that I did was a 2-d (sic) shape." Another student chose a more adventurous shape and wrote "The decahedron (sic) has 10 sides, 10 vertices and 10 obtuse angles. The decahedron is the shape of a 50c coin." In both of these examples, students were focussing on a list of disconnected features, relying solely on visual cues. The lack of use of geometrical language and the incorrect use of terms in their final published work could suggest that the interactions between teacher and students did not assist them to develop their thinking. Nevertheless, the students' confidence in choosing "cool" shapes such as octagons was encouraging in its motivation.

A year 4 student provided several representations of a pyramid using a computer drawing package. This student had previously used the school pad to draw 2D representations of 3D objects. The representations are shown in Figure 1, and include a birds-eye view of a rectangular pyramid as well as a tetrahedron and an attempt at drawing a square-based pyramid. This example indicated a more sophisticated outcome. Representing accurately 3D objects in a 2D form is not a trivial task for young students. Agnes, the teacher involved, explicitly linked concrete objects, skeleton models of these using play dough and matchsticks, virtual representations using the school pad and isomorphic dot "paper", and the language of geometry in her questioning and review at the start and end of the lesson. Technology use is not independent of the teacher, although Agnes reported that once the students were familiar with the technology she left them alone using the school pad while she worked with other groups.

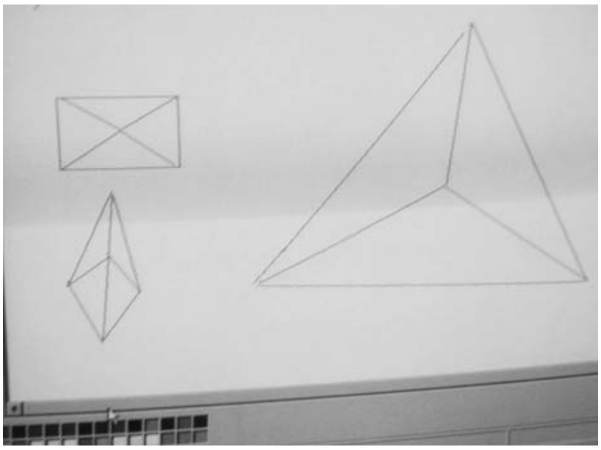

Figure 1. Computer representations of pyramids.

Three common themes emerged at the teacher meetings. The first was the difficulty of getting underway with the technology. Apart from Mark in School A, who had a large IWB fixed in his classroom, the other schools had no experience in IWB use and did not have appropriate hardware easily available. Although all schools possessed data projectors, and teachers had laptop computers, accessing the projector was not easy. It often involved planning ahead and booking the projector for a given time. These difficulties, on top of coming to terms with new teaching approaches and a new tool, proved challenging.

The second issue was teachers' relative lack of understanding of geometry. There were often comments such as "I hadn't realised that" or "I have never been taught this" when they were undertaking tasks designed to focus on geometrical understanding. Although all the teachers involved were widely experienced they readily acknowledged gaps in their mathematical knowledge.

Another issue that became evident in the meetings was the perceived motivational power of IWB technology. The teachers reported that the students repeatedly commented on the "fun" nature of the equipment and their desire to use it again. There were multiple comments on the manner in which the IWB enhanced the students' interest level during mathematical activities. The students' work samples endorsed this impression with comments such as: "Using the interactive whiteboard was a bit challenging but was fun when you put your mind to it. It was a very fun activity to do" and "I enjoyed using the Interactive Whiteboard. At first it was hard but after a while it became easy. It was lots of fun! ☺".

Discussion

Research Question 1

The reason for using school pad technology, as opposed to large fixed IWBs, was to encourage interaction among students. Of the three teachers observed, only Agnes was using this pedagogical approach. It is interesting to note that although Agnes did not have access to a fixed IWB and initially described this as a limitation, the collaborative small group tasks she designed which utilised the student pad were constructivist in nature and allowed the students to formulate and discuss their mathematical ideas. It was evident that the initial use of IWB technology as a large display in the classroom led to a tendency for the teacher to adopt transmission style teaching approaches, with the focus of the activity concerning the development of new technological skills. There were benefits in students having direct access to the student pads during geometrical activities in association with other concrete materials. A combination of small group constructions, electronic geoboard constructions, and recording of known properties and relationships was observed as an effective strategy. In addition, the time taken to bring the groups of students together as a class and discuss the ideas formed and language used was invaluable. This finding is consistent with those reported by Moss et al. (2007), and emphasises the comments of Deaney et al. (2003).

There were positive factors in relation to the motivational aspects of IWBs, but the "fun" and "pretty" side of the mathematical activities appeared to impinge on the development of mathematical concepts. Although the students enjoyed presenting mathematical concepts in a variety of technological forms, the display emphasis lost sight of the potential of the equipment as a teaching tool. The effective lessons engaged the students in mathematical investigations and problem-based learning tasks, without an emphasis on producing a display such as slides or booklets, in line with Fitzallen's (2005) thinking.

In terms of geometry specifically, although teachers did use aspects of the provided software, this use appeared to be limited to drawing, or interactive games. David, for example, used the geometric shapes to produce tessellations but this provided a digital mimicry of the use of pattern blocks and did not seem to lead to a deeper understanding of the conditions under which a shape would tessellate. Such use locks students into lower levels of thinking, but this may also have been reinforced by the teachers' own perceived lack of knowledge. Complex dynamic geometry software is not appropriate for use in primary schools, and many of the interactive activities and games available can be undertaken successfully with an inefficient "trial-and-error" approach, encouraged by the speed of the IWB interface. A new approach is called for to utilise the power of the IWB interface.

It appeared that IWB technology was motivational and encouraged students' interest. Unless careful thought was given to the pedagogy, however, student learning was not greatly enhanced and the potential gains from their increased interest not realised.

Research Question 2

The issues that emerged during this small, initial study were not unexpected. Access to appropriate infrastructure was critical and the time teachers took to get underway with the project was increased when this support was not available. The technology of itself was not effective unless teachers carefully planned and thought through their teaching approaches. The professional development sessions were important to support teachers' growing understanding of appropriate pedagogical approaches, in line with research findings from elsewhere (Hall & Higgins, 2005).

The finding that the large wall-mounted IWB was more consistent with teacher-centred approaches was also indicated in the literature (Moss et al., 2007). The small school pads, used appropriately, did appear to have potential for encouraging student-student and student-teacher interaction, and this may be a fruitful area for further research.

The call for a framework for conducting technology-rich lessons (Chua & Wu, 2005) was also borne out by the findings. Teachers appreciated the value of the van Hiele (1986) teaching phases and the SOLO model (Biggs & Collis, 1982), but in this short study were able only to develop a surface understanding of the possibilities. Nevertheless, the use of such frameworks to develop lessons using technology appears to have potential.

Conclusion

Through these case studies, it appeared that student-centred mathematical activities that used IWB technology as a teaching tool, required the teacher to facilitate tasks considered to be the most appropriate place to use the IWB within a developmental teaching sequence. The students enjoyed direct access to the equipment regardless of the task, but gained most benefit when actively involved in tasks which challenged their mathematical thinking and allowed for communication with their peers. The technology tasks were embedded in a range of activities that explicitly addressed different phases of the van Hiele teaching sequence. There was a tendency to rely on the display nature of IWBs in the classroom, leading to lessons where the final result of the activity was the display of pre-existing student ideas. The case studies also emphasised the need to provide sustained professional development which focused on the place of IWB technology in the light of known developmental frameworks in mathematics education, providing a useful platform for further research.

Acknowledgement. This study was supported by the Australian School Innovation in Science, Mathematics and Technology (ASISTM) program.

References

Biggs, J. B., & Collis, K. F. (1982). *Evaluating the quality of learning: The SOLO taxonomy*. New York: Academic Press.

Chua, B., & Wu, Y. (2005). Designing technology-based mathematics lessons: A pedagogical framework. *Journal of Computers in Mathematics and Science Teaching, 24*(4), 387-403.

Clarke, D. M., Cheeseman, J., Gervasoni, A., Gronn, D., Horne, M., McDonough, A., Montgomery, P., Roche, A., Sullivan, P., Clarke, B., & Rowley, G. (2002). *Early Numeracy Research Project Final Report, February 2002.* Fitzroy, Victoria: Australian Catholic University.

Coffland, D. A., & Strickland, A. W. (2004). Factors related to teacher use of technology in secondary geometry instruction. *Journal of Computers in Mathematics and Science Teaching*, *23*(4), 347-366.

Davey, G., & Pegg, J. E. (1992). Research in geometry and measurement. In B. Atweh & J. Watson (Eds.), *Research in mathematical education in Australasia 1988-1991* (pp. 231-247). Brisbane: MERGA.

Deaney, R., Ruthuen, K., & Henessy, S. (2003). Pupils perspectives on the contribution of information and communication technology to teaching and learning in the secondary school. *Research Papers in Education, 18* (2), 142-160.

Fitzallen, N. (2005). Integrating ICT into professional practice: A case study of four mathematics teachers. In P. Clarkson, D. Gronn, M. Horne, A. McDonough, R. Pierce, & A. Roche (Eds.) *Building connections: Research, theory and practice* (Proceedings of the 28th annual conference of the Mathematics Education Research Group of Australasia, pp. 353-360). Sydney: MERGA.

Hall, I., & Higgins, S. (2005). Primary school students' perceptions of interactive whiteboards. *Journal of Computer Assisted Learning*, *21*, 102-107.

McGehen, J., & Griffith, L.K. (2004). Technology enhances student learning across the curriculum. *Mathematics Teaching in the Middle School, 9* (6), 344-349.

Miles, M.B., & Huberman, A.M. (1994). *Qualitative data analysis*. (2nd ed.) Thousand Oaks, CA: Sage Publications.

Moss, G., Jewitt, C., Levaaic, R., Armstrong, V., Cardini, A., & Castle, F. (2007). *The interactive whiteboards, pedagogy and pupil performance evaluation: an evaluation of the schools' whiteboard expansion (SWE) project: London challenge*. London: Institute of Education.

Olive, J. (1991) Logo programming and geometric understanding: An in-depth study. *Journal for Research in Mathematics Education*, *22*, 90–111.

Pegg, J. E., & Davey, G. (1998). A synthesis of two models: Interpreting student understanding in Geometry. In R. Lehrer & C. Chazan (Eds.), *New directions for teaching and learning geometry* (pp. 109–135). Mahwah, NJ: Lawrence Erlbaum.

Serow, P. A. (2002). *An investigation into students' understandings of class inclusion concepts in geometry.* Unpublished doctoral dissertation, University of New England, Armidale.

Serow, P. (2006). Triangle property relationships: Making the connections. In J. Novotná, H. Moraová, M. Krátká, & N. Stehliková (Eds.) *Proceedings of the 30th conference of the International Group for the Psychology of Mathematics Education* (Vol. 5, pp. 89-96). Prague: PME.

Smith, F., Hardman, F., & Higgins, S. (2006). The impact of interactive whiteboards on teacher-pupil interaction in the National Literacy and Numeracy Strategies. *British Educational Research Journal*, *32*(3), 443-457.

Stake, R. E. (1995). *The art of case study research*. Thousand Oaks, CA: Sage Publications.

Tanner, H., & Jones, S. (2007). Learning from children about their learning with and without ICT using video-stimulated reflective dialogue. In J. Watson & K. Beswick (Eds.), *Mathematics: Essential research, essential practice.* (Proceedings of the 30th annual conference of the Mathematics Education Research Group of Australasia, pp 208-716). Sydney: MERGA.

van Hiele, P. M. (1986). *Structure and insight: a theory of mathematics education*, New York: Academic Press.