Pedagogy and Interactive Whiteboards: Using an Activity Theory Approach to Understand Tensions in Practice

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In studying the use of Interactive Whiteboards (IWBs) we have observed that there are concerns in relation to measures of pedagogy. Using a productive pedagogies framework to analyse the use of IWBs in middle school classrooms, we found very low rating on aspects of pedagogy related to intellectual quality. Using an activity theory framework, and drawing on observations and interview data, we theorise the tensions in the uptake and use of IWBs to support mathematics learning.

Promoters of IWBs have been very strategic in the use of case studies to illustrate the novelty and support that can be achieved through the clever use of the tool (Edwards, Hartnell, & Martin, 2002). However, as reported elsewhere (Zevenbergen & Lerman, 2006), there are notable concerns in terms of how the IWBs are used in Australian classrooms. In this paper, we draw on these contradictions with the use of IWBs to theorise the use of IWBs. Drawing on the principles of activity theory to frame the analysis, we draw particularly on the notion of tools, in this case IWBs, which mediate pedagogic relationships. Within activity theory, tools can refer to both concrete and semiotic tools. As such, we draw on a range of tools that can be used to explain the complex milieu of classrooms and the uptake of IWBs. The values and beliefs that teachers hold about pedagogy and/or technology mediate the ways in which they will use such technologies. The beliefs and values may relate to the pedagogical approaches that are adopted or to the technological tools themselves. Where teachers hold particular views about how children best learn mathematics, then they are most likely to employ strategies that align with those beliefs. Similarly, if they see technology as a tool that can undertake particular functions (such as a calculator can be used for working out arithmetic tasks), then the technology will be used in that fashion. In exploring computer-mediated learning using activity theory, Waycott, Jones, and Scanlon (2005, p. 107) reported that there is a reciprocity between the tools and the learner where "the user adapts the tools they use according to their everyday practice and preferences in order to carry out their activities; and how, in turn, the tools themselves also modify the activities that the user is engaged in." Drawing on activity theory, we explore the ways in which IWBs were used in a number of classrooms, provide an evaluation of the approaches being used by teachers, and then seek to explain the observations that were made in these classrooms.

Interactive Whiteboards as Mediating Tools: A Background

The implementation of interactive whiteboards in schools in the UK has been strongly supported by the government (Beauchamp, 2005) with over £50m being spent on their implementation in primary and secondary schools (Armstrong et al., 2005). However, it has not received the same fiscal support in Australian schools. Many schools are supporting the implementation of these devices through various means but without systematic support. In most cases, the implementation of IWBs is a school-based decision and as such is supported by funds raised by the schools. How the IWBs are implemented within a given

school is dependent upon the resources of the school to provide the equipment and the beliefs of the teaching staff as to the value of the tool. As such, there is considerable variation across Australia as to their uptake and implementation. This can range from how IWBs are placed in classrooms (who has them and where they are physically located), how teachers use them, and access to professional development.

In taking up new forms of technology Glover and Miller (2002) reported that their experienced teachers were skeptical of these new forms of pedagogy whereas, in contrast, preservice teachers saw these new technologies as an integral and valued component of their future practice. In the process of moving from the novice user to one who integrates the IWB into their repertoire of pedagogic skills, Beauchamp (2005) contends that there needs to be a considerable investment for teachers to learn to develop their technical competence alongside their pedagogical skills. In terms of how the IWB is used in the classroom, Glover and Millar (2002) contend that teachers need to recognize that there is considerable interactivity associated with the use of IWBs. They argue that the IWB can engender an approach that fails to radicalize pedagogy and where the IWB is used to enhance students' motivation rather than become a catalyst for changing pedagogy. To be competent with the use of IWBs, it was recommended that teachers need daily access to such tools (Armstrong et al., 2005) so that teachers are able to develop their repertoire of skills and to integrate it into practice (Glover & Miller, 2001). Greiffenhagen (2000) argued that the availability of IWBs as a teaching aid is only of value where it becomes part of the regular pattern of classroom life. Others argue that teachers also need to have access to a wide range of software and applications that are subject specific (Armstrong et al., 2005) and that on-going training with the use of IWBs helps teachers develop their skills and knowledges with regard to the affordances of these tools.

Changing Technology, Changing Pedagogy?

In considering the impact of IWBs on classroom practice, Smith, Hardman, and Higgins (2006) reported that there is a faster pace in lessons using IWBs than non-IWB lessons, that answers took up considerably more of the overall duration of a lesson, and that pauses in lessons were briefer in IWB lessons compared with non-IWB lessons. They also reported a faster pace in numeracy lessons than in literacy lessons. Although they reported some support for the potential of IWBs, they concluded that overall the use of IWBs was not significantly changing teachers' underlying pedagogy. The majority of teacher time was still spent on explanation and that recitation-type scripts were even more evident in IWB lessons. They found that although the pace of the lessons increased, there had been a decline in protracted answers from students and that there were fewer episodes of teachers making connections or extensions to students' responses.

Although there is a suggestion that IWBs have considerable potential to change interactions and modes of teaching, this has not been found to the case in practice (Smith, Hardman, & Higgins, 2006). These authors claim that there is a faster pace in lessons but less time is being spent in group work. There is a tendency for teachers to assume a position at the front of the class when using IWBs (Maor, 2003). Similarly Latane (2002) suggests that there needs to be a move from teacher-pupil interaction to one of pupil-pupil interaction. In studying mathematics classrooms, Jones and Tanner (2002) reported that interactivity can be enhanced through quality questioning where the quality of the questions posed and the breadth of questioning need to be developed to ensure interactivity in mathematics teaching when using IWBs.

IWBs and Activity Theory

The literature alerts us to the affordances and constraints of this new technology. In considering this within the context of activity theory, we are particularly drawn to third generation activity theory Engeström's third generation framework (e.g., 2000, p. 31), where the mediating tools were extended and elaborated substantially to identify the participants and resources present in an activity, and their different roles and responsibilities. His elaborate representation of these elements and their connections enables an identification of tensions and contradictions in activity systems and hence the potential for development. His model of activity is represented in Figure 1.

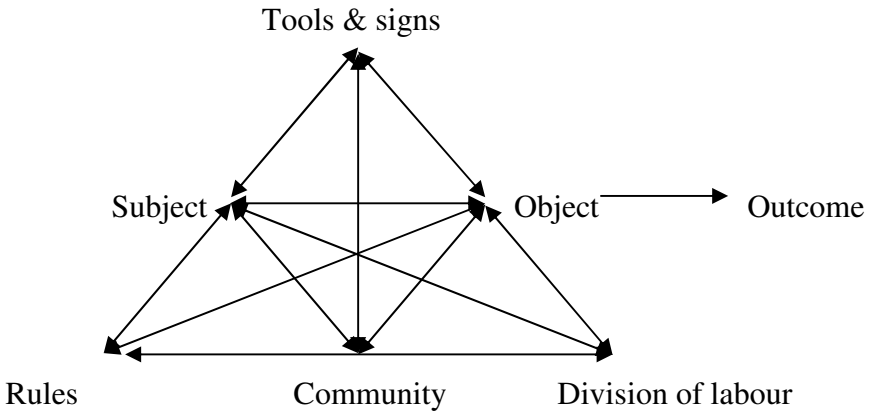

Figure 1: Engeström's third generation activity theory.

The model proposed by Engeström extends the work of Leont'ev so as to consider not only the tension and contradiction between points in the framework but also the context within which learning occurs. For us, the theory allows us consider the results we have observed as being related to these tensions. We draw on this model to understand better the outcomes of this research. It allows us to theorise more constructively the analysis made possible through the analytic lens which we applied to the classroom videos. Rather than explain our outcomes in some deficit framing, Engeström's proposition allows the tensions within the activity system – in this case, classrooms – to be understood more holistically.

Data Collection

The research reported here is drawn from a much larger study where we were concerned with the ways in which technology (ICTs) were being used to support mathematical learning in the middle years of school. As this larger project unfolded over the four years of data collection, we were fortunate to see the introduction of IWBs into some of our participating schools. This provided an intended aspect to the project. The process for data collection involved teachers or someone from the research team taking video of lesson where teachers used ICTs or, more specifically for this paper, IWBs. These tapes were subsequently analysed using a productive pedagogies framework.

When using this well documented framework on the IWB lessons, there were many worrisome scores when teachers used IWBs in mathematics lessons. To better understand this outcome, we returned to the schools to interview teachers, and returned to the tapes to undertake observations of those lessons. For the IWB aspect of the project, we had two

schools using the tools – one in Queensland and one in Victoria. Across these schools, five classrooms were using IWBs.

Descriptive Overview of Pedagogy

In viewing the tapes, a number of commonalities were evident in the observed lessons. Our data confirmed the research of Smith, Hardman, and Higgins (2006) where we observed the level of questioning being used by teachers in these lessons. There were more recall questions than those requiring deeper levels of understanding. This type of questioning also allowed for a quicker pacing of the lesson since teachers were able to ask quick fire questions where there was little depth in the responses required. The predominant approach used by teachers when using the IWBs was that of whole class teaching. In these settings, the teacher controlled the lesson, inviting students to participate in manipulating the objects. In all cases, the teachers used the IWBs as the introduction to the lesson. Once the students had been involved in the introductory component of the lesson, they returned to their desks to work on activities related to the topic being introduced. Depending on the resources used by the teacher, there were instances where the IWB made possible a rich introduction to aspects of mathematical language.

Productive Pedagogies Analysis

Although the observations provided us with some indicators of how the IWBs were being used in the classroom, we also employed a quantitative measure to document the use of IWBs. This measure allows us to analyse the lessons more rigorously. We have used this approach in analyzing the use of ICTs in classrooms so were able to compare those data against the use of IWBs. The process involves three observers observing the lessons that had been videotaped. Each observer rates the lesson against nominated criteria on a scale of 0-5 where 0 indicates that there was no evidence of that criterion in the lesson and 5 indicates that it was a strong feature that was consistent throughout the lesson. The ratings are made at the completion of the lesson and the score is for the overall lesson. If there is some evidence of a criterion in the opening phase of the lesson but does not appear again, then this means that it was not a strong feature of the overall lesson. The three observers rate their observations independently and then come together to come up with a common score. This involves a process of negotiation to arrive at the common outcome. In most cases, there was usually a difference of 1 between the ratings and the ensuing discussion meant that the observers needed to negotiate their ratings with the other two. The framework we have used come from the work of the Queensland Schools Longitudinal Reform Study (Education Queensland, 2001) in which the researchers analysed one thousand lessons in terms of the pedagogies being used by teachers. The method was that described above and where the criterion for each rating was based on the Productive Pedagogies. There are four dimensions within the framework – Intellectual Quality, Relevance, Supportive School Environment, and Recognition of Difference – in which there are a number of pedagogies that are evident of that theme. The Productive Pedagogies are outlined in Table 1.

Table 1
Productive Pedagogy Dimensions, Items and Key Questions (from Gore, Griffiths, & Ladwig, 2006)

	Productive Pedagogy	Key question
Intellectual quality	Higher order thinking	Are higher order thinking and critical analysis occurring?
	Deep knowledge	Does the lesson cover operational fields in any depth detail or level of specificity?
	Deep understanding	Do the work and response of the students provide evident of understanding concepts and ideas?
	Substantive conversation	Does the classroom talk break out of the initiation/response/evaluation pattern and lead to sustained dialogue between students, and between students and teachers?
	Knowledge as problematic	Are students critiquing and second guessing texts, ideas, and knowledge?
	Metalanguage	Are aspects of language, grammar and technical vocabulary being foregrounded?
Relevance	Knowledge integration	Does the lesson range across diverse fields, disciplines and paradigms?
	Background knowledge	Is there an attempt to connect with students' background knowledge?
	Connectedness to the world	Do lessons and assigned work have any resemblance or connection to real life contexts?
	Problem based curriculum	Is there a focus on identifying and solving intellectual and/or real world problems?
Supportive School Environment	Student control	Do students have any say in the pace, direction or outcome of the lesson?
	Social support	Is the classroom a socially supportive, positive environment?
	Engagement	Are students engaged and on-task
	Explicit Criteria	Are criteria for student performance made explicit?
	Self regulation	Is the direction of students' behaviour implicit and self-regulatory?
Recognition of difference	Cultural knowledges	Are diverse knowledges brought into play?
	Inclusivity	Are deliberate attempts made to increase participation of all students from different backgrounds?
	Narrative	Is the teaching principally narrative or expository?
	Group Identity	Does teaching build a sense of community and identity?
	Citizenship	Are attempts made to foster active citizenship?

Gore et al. (2006) argue that the productive pedagogies framework is most useful as a tool for reflecting on practice. In analysing the classroom video, two or three researchers observed the lesson using the categories to rate the overall lesson. A scale of 0[1] (not a feature of this lesson) through to 5 (an integral part of the lesson) were scored for each lesson. These were undertaken independently by the members of the research team. Once the lesson had been completed, the team met to view their ratings and to come to a

[1] This model has been validated by the QSLRS team and where each score is more clearly articulated than is possible within this paper.

consensus on the score. In most cases, the scores were very similar so there was little negotiation. However, there were a number of instances where there was considerable debate but this was often centred on clarification of the definitions and the perceptions around whether the score could be applied to the full lesson.

Within the Productive Pedagogy approach, there is a strong emphasis on raising the quality of teaching in terms of the intellectual experiences and the social learning. The outcomes of the Queensland study (Education Queensland, 2001) indicated that teachers were very good at providing a supportive learning environment but that the intellectual quality was quite poor. When the analysis was undertaken across key learning areas, it was reported that the learning environments in mathematics scored the least favourably suggesting that the intellectual quality in mathematics (across all years of schooling) was poor.

Scoring IWBs – New Pedagogy or Problematic Pedagogy?

In seeking to explore the use of IWBs in mathematics classroom, we undertook the same analysis of the classroom videos. As can be seen in Table 2, the scores are low in most areas. We have included the analysis of classroom data where ICTs were used in mathematics classrooms as a comparison.

Table 2
Productive Pedagogy Analysis of IWB use in Upper Primary Classrooms.

	ICTs		IWBs	
Dimension of Productive Pedagogy	Mean	SD	Mean	SD
Depth of knowledge	1.64	1.36	1.5	1.46
Problem based curriculum	2.19	1.38	*0.92*	0.83
Meta language	1.69	1.07	1.25	1.87
Background knowledge	1.76	1.16	1.67	1.63
Knowledge integration	1.48	1.27	*0.42*	0.45
Connectedness to the world	1.38	1.44	*0.42*	0.45
Exposition	1.19	1.64	0.83	0.82
Narrative	0.31	0.78	0.17	0.18
Description	2.24	1.02	*1.42*	1.25
Deep understanding	1.43	1.47	1.25	1.19
Knowledge as Problematic	1.14	1.47	1.33	1.36
Substantive conversation	1.26	1.40	*0.5*	0.46
Higher order thinking	1.31	1.55	1.33	1.36
Academic engagement	2.23	1.38	*1.5*	1.46
Student direction	0.79	0.92	0.33	0.28
Self regulation	3.24	1.12	*2.5*	2.45
Active citizenship	0.30	0.78	0	0
Explicit criteria	2.83	1.17	*1.33*	1.28
Inclusivity	0.33	0.75	0	0
Social support	2.51	0.25	*1.25*	0.62

These data indicate that when using the IWBs as a pedagogical device, their effectiveness may be somewhat limited. We have reported the data for when teachers used ICTs to support numeracy learning elsewhere (Lerman & Zevenbergen, 2006) and this showed very low levels of quality learning potential. However, when using the same framework to analyse the use of IWBs, the results are even lower. Nine out of the twenty pedagogies (those in italics) scored substantially lower when using IWBs. Most of the

lower scores were in those two dimensions that relate to the intellectual aspects of mathematics learning. From these data we can conclude that the use of IWBs actually reduces the quality of mathematical learning opportunities, provides fewer opportunities for connecting to the world beyond schools, and offers little autonomous/independent learning opportunities for students. Because these data are alarming in terms of their low scores, we sought to understand the phenomenon noted earlier in this paper. Whereas the low scores would suggest that there was potential for low levels of mathematical learning, our observations of the lessons indicated that despite these perceived low scores, there were few behaviour problems with students.

Activity Theory: Coming to Understand the Use of IWBs

In this final section, we analyse, using Activity Theory, the outcomes in the productive pedagogies table alongside interview data and classroom observations. We focus on the notion of the artifact mediating learning. Within activity theory, signs and tools mediate learning so, in our case, the IWBs were seen as artifacts that shape the ways in which learning can occur. The teachers found the resources that were available through the IWB – such as pre-planned lessons and digital tools (protractors, rulers, etc.) – offered different ways of working with the students. Not only were the resources shaping the ways in which teachers taught and planned, but also they impacted on other aspects of their work.

> Shane: I find that there are a whole lot of really good lessons that I can just use. If I am doing something on area for example, there are lessons already made up. Some other teachers have developed them so they have to be good ones. I am sure that the company only puts up the best examples. I have found these to be very handy and they save me doing the preparation work. I guess I change them a bit to suit me and the kids but they are pretty much there.

Most of the teachers had some comment about the time factor in the use of IWBs. It was seen to save preparation time in two different ways. As evident in the comment by Shane he drew on the resources that had been made by other teachers as these were "tried and proven" examples of lessons that worked. In observing his lessons, he would select from the databank and then implement the lesson. Another teacher commented on how, when using the IWB, the toolkit meant that the resources were all in the one place so she did not have to hunt around for them. Knowing that the protractor, ruler, clock, calculator were all on the screen and at the touch of the board, was seen to be a considerable timesaver. Other teachers made similar comments about the tools that were available on the IWB.

> Sarah: I think that the tools on the whiteboard are just great. They are done in a way that the children like them. When I pull up the calculator, for example, it looks exciting. It is much more interesting than the overhead projector type. I think that these kids expect a bit more from their computers and this is possible with the interactive whiteboard.

These built-in tools were seen to help teaching by reducing time spent not only on preparation of lessons but also within the lesson. This helped to make for a quicker pacing of lessons. The quicker pace was seen to enhance learning opportunities by engaging students. When using the IWBs, it would appear that the teachers were aware of the faster pace of the lessons. Having the ready-made resources available meant that little time was "wasted" moving from one site to another or drawing representations on the traditional boards or papers. They articulated that they posed a lot more questions and the students had greater opportunities for participating in the lessons due to the increased questioning.

> Maxine: One of the things that I like about the whiteboards is that I can ask a lot more questions. You just have to click on the menu and there is the lesson or the things you need so you are not wasting a lot of time putting up overheads or drawing things on the board. I can ask more questions to the kids to see what they know and to get them to think about things. Like when we did the lesson with the clocks. You just click on the clock and there it is. You can just move the time around as quick as they kids respond. I think they like the quicker speed. They seem to enjoy the race of the lesson. If they answer quickly, then we can do another one or something a bit different

The IWB offers other potentials that were not possible in previous media. In the following observation of a lesson, we were able to see how the accuracy of the IWB makes the teaching of fractions possible in new and novel ways.

> While the teacher poses the questions, these are teacher-initiated questions and tend to be of a low level- that is, recall-type questions. Observing a lesson on fractions, the teacher had used the fraction creator. In this, the teacher used the circle and made various numbers of segments. With each new model of fractions, she posed questions including "How many pieces are there?" "What fraction is that?" The pacing of questions was faster than would be possible if the teacher were to draw the objects on the board and then create sections. What was possible in this format was that the accuracy of the sections made for less confusion as to the size (and hence equality in those sizes) but also made possible the more difficult representations (such as sevenths or fifths). (Lesson Observation)

However, although the accuracy of representation was a strength of the IWB, it is noted that the overall pedagogy remained similar to most lessons we have observed in the more traditional modes of teaching. The depth of questioning remained at a relatively superficial level where low levels of questions were posed. Thus there remained considerable tension in what was offered and what could have been asked. While some aspects of pedagogy had changed, others had remained in place.

One of the observations in the use of IWBs was that it seemed to be used for the introduction to the lessons. In following this observation, teachers were asked if this were the case and if so, why. In the interviews, it was confirmed that the teachers tended to use the IWB to orientate the lesson and to motivate the students.

> Heidi: I use it to get the lesson started. The kids are all together, there are all on the one task, they know what we are doing. That is a good way to start the lesson. It is also good as the kids are very motivated by the boards so they are keen to get into the lesson.

In examining the role of the artifact one must also ask what it is replacing, both physically and in how it used during teaching. The IWB largely replaces the standard whiteboard in that whilst it is also available for pupils to be called to the board to present their ideas, proposals, and outcomes of their problem solving, it can also be used to present content previously prepared and it enables the teacher to choose high quality accurate representations as they are called for during the progress of the lesson. The IWB enables the same variety of font formats and other visual effects as word processing packages too. In most classrooms the whiteboard remains on the wall alongside the IWB. There is some sense that the students in classrooms expect a higher level of digital media in their lives. Following one lesson where the teacher had been working with some number work and using the calculator, we discussed the approach and what was offered through the IWB environment that would not be possible with the non-digital environments. In the case being observed, it was posed that the same learning could have occurred had the teacher used the traditional whiteboard and an overhead projector, which would have been a substantially cheaper option. The teacher commented as follows.

> Marcie: What I think is the key to this is that the calculator is already there. I click it on and there it is. I don't have to walk to the OHP and use that medium. There is no time being wasted. The

> calculator (on the IWB) is a neat one and the kids like it. I think that they are so savvy with technology that they come to expect that, you know, the instant appearance of things – like the calculator. They get turned off by wasting time moving around, they like things to come up at the touch of a key. They just expect it, they have grown up with computers and they just expect that that is the way the world is.

The overhead projector (OHP) can be used to project pre-prepared transparencies onto the whiteboard but in our experience in these schools the OHP is rarely used. Our observations indicate the predominance of the latter two uses of the IWB, pre-prepared materials and impressive formats, causing some frustration amongst pupils as they want to "have a go" at using the IWB themselves. Writing on the whiteboard is a slow process, calling for the teacher to be turned away from the pupils. Projecting PowerPoint work or other resources sets up fast paced lessons and greater control of pupils' behaviour.

Thus the key tension here appears to be between the artefact and the division of labour. Although it is clear that the IWB offers great potential for higher level interactions between teacher and pupils, the need to be in control of the class and in this case the artefact militates against any pedagogic shift towards greater intellectual challenge. The identification of this tension also opens up the possibility for development with teachers; the specific focus offers a way in to engagement with what is blocking a positive move.

Conclusion

There is little doubt that IWBs have the potential to enhance learners' opportunities to experience mathematical representations and develop their mathematical thinking. As with all resources, mathematical or other, internalising a tool, be it the number line or a calculator, LOGO, dynamic geometry or Graphic Calculus, or presentation tools such as overhead projectors or IWBs, transforms the world, in this case of mathematical pedagogy for the teacher. That transformation is always mediated by other experiences; however by themselves they will not transform pedagogy, no matter what their potential. Indeed, as we have reported in this paper, the technologically impressive features of the IWB can lead to it being used to close down further the possibility of rich communications and interactions in the classroom as teachers are seduced by the IWB's ability to capture pupils' attention. We suspect, also, that teachers' advance preparation for using the IWB, often via the ubiquitous PowerPoint package or pre-prepared lessons for the IWB, are leading to a decreased likelihood that teachers will deviate in response to pupils' needs and indeed might notice pupils' needs less frequently through the possibility to increase the pacing of mathematics lessons.

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