SHARED COGNITION FACILITATED BY TEACHER USE OF INTERACTIVE WHITEBOARD TECHNOLOGIES

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ABSTRACT

This paper reports on a study designed to examine the dialogic processes teachers used to sustain focused discussions, using questioning techniques and Interactive Whiteboards (IWBs). IWBs and their related technologies such as plasma touch screens and projected tablets have passed through several phases of implementation as classroom objects, from initial adoption by a few enthusiasts, through the building acceptance phases, and finally a phase of maturity characterized by widespread use. This study shows that teachers who value shared collaborative learning spaces, can draw on distributed cognition, and promote sustained thinking, cognitive engagement and that this enables development and refinement of students insights.

KEYWORDS

Interactive Whiteboards, Shared Cognition, Dialogical teaching moments,

1. INTRODUCTION

When IWBs were first introduced, the early studies in the United Kingdom focused on pedagogies related to interactivity that involved teacher and students, and between students (Smith et al, 2006; Tanner et al, 2005; Moss et al, 2007). Teachers tried to realize the affordances of IWBs. Criticisms focused on IWBs easily being absorbed into the existing practices of teachers without pedagogical changes, and reflected past practices of teachers. A major UK study concluded "IWBs are mainly being used: as a data projector which can navigate to multiple screens; as a surface which can generate a dynamic rather than static form of display; to enhance presentation from the front of the class" (Moss et al, 2007 p. 5). IWBs may have lead to less thinking time when the teacher retains control. This study sought to see if more thinking time could happen.

Studies have tried to evaluate the IWBs impact on pedagogy, on uses to reinforce whole class teaching, and teacher engagement with the "surface features" of interactive teaching (Rudd, 2007; Smith, Hardman & Higgins, 2006); Mercer, Hennessy & Warwick, 2010). Others are equivocal, while claiming some positives. Warwick and Kershner, (2008), commented: "Research evidence on educational gains from IWB use across both primary and secondary phases of schooling is mixed" (p.269).

There has been limited understanding about how pedagogy develops with IWBs in the UK, USA and Australia (Hennessy et al 2007). In Australia attempts to classify IWB impacts in terms of a hierarchy of pedagogical skills, led to questions of whether the affordances of the technologies could stimulate higher order thinking skills through interactivity (Vincent & Jones, 2008; Sweeney, 2008)), similar to other studies quoted here, these sought to examine the impact of the technology in changing pedagogy.

This paper presents one teacher's use of the IWB to support shared cognition. Perhaps earlier disenchantment with IWBs arose because the wrong question was being asked: what can the technology do *for* teachers/students? A more useful question might be: what can the technology do *with* me/students? This teacher's lesson review indicates that she works *with* the affordances of the technology, to support dialogically meaning making moments in her classroom. Her pedagogical work aligns with the seven pedagogical practices for using technologies (Osborne and Hennessy, 2003). This teacher's in class voice, and again her voice in the interviews, indicates she understood that a shared language needed to be created before students could engage in discussions, and before they could question and think about what was happening (Redman, 2010). Her class can be seen to be working with ideas afforded by the teacher using the

IWB, because they have the necessary language needed to enter collaborative and challenging thinking spaces.

Luckin (2008) and Beauchamp (2011) used the same concept of 'working in partnership' with machines. This is done with a view to redefine and enhance performance as noted by Salomon, Perkins and Globerson, (1991), now this includes IWBs and digital interactive technologies. Luckin and Beauchamp also take account of the local setting and culture within which tools are embedded. Luckin (2008, p 451), describes learning taking place within an ecology of resources, 'a set of inter-related resource elements, including people and objects, the interactions between which provide a particular context'. This message, with a few exceptions, became lost in the euphoria of the early adoption of IWBs. It is now being re-examined.

A possible pedagogical contribution that IWBs can make to pedagogy practices is by enabling students to work through their ideas both verbally, and, graphically. Warwick and Kershner (2008) report on a teacher who linked the IWB's multimodality affordances with the IWB, using it as "supportive of the collective memory of the group" (p. 276). The thinking of the user is made visible to all, empowering students to more effectively, and knowingly, participate in collaborative reasoning and hypothesis testing that may well "go well beyond those afforded by more established classroom devices…. [the IWB] provides a dynamic and manipulable object of joint reference which offers new forms of supports for 'intersubjectivity'" (Hennessy et al, 2007 p.284).

Hennessy has shown IWBs assist teachers development of a culture of shared dialogue leading that can lead to 'shared cognition' in classrooms (Hennessy et al, 2014). Notably, Hennessy is reporting on a study that was conducted with teachers who already had belief and practices revolving around student dialogue. The project concluded that when teachers purposefully create the right conditions to support risk taking and changing of minds, rich new forms of dialogue and activity emerge, and both at the board and away from it. Hennessy states the pre-existing teachers' views about learning, and the classroom cultures they nurture, are central to developing the more productive dialogic uses for IWBs. Their willingness to at least partially relinquish control over the IWB and to take the time to consider students' views was identified as critical. This suggests that a dialogic culture has to exist first.

Classroom situations in which collective intelligence and shared cognition can potentially be fostered through IWB use is reported on by Alvarez et al (2013). Harnessing group intelligence to extend students' productivity and depths of understanding, and of distributed cognition by sharing thinking and insights appears to be possible only once the teacher creates a shared platform. These are affordances offered by the IWB, and other devices. These activities were rarely seen, or documented, in the early phases of IWBs use, noted by most of the authors already mentioned.

Alvarez et al (2013) observed Swedish teachers, in upper primary schools, use a framework that supported collaborative and shared solutions. Using the IWB, teachers provided students opportunities to share and deepen their thinking. These students reported that they "had a better understanding of how to solve a problem as a result of the greater communication they had with their peers and their teacher" (p. 376).

2. METHODOLOGY

2.1 Project Outline, Participants and Data Collection

This project originated as part of ongoing research within the Melbourne Graduate School of Education on the quality of teacher-student interactions and teacher-teacher with technologies generally (Chandler & Redman, 2013; Delaney, Trapani, Chandler & Redman, 2014). It sought to examine the dialogic processes in three classrooms in a primary school when confident teacher IWB users incorporate technologies. In depth reporting on a classroom teacher and her interpretations of her actions are reported on and examined here. Drawing on the work of Hennessy et al (2014) and Mercer, Hennessy & Warwick (2010) the project focused on how teachers developed skills mediated by the IWB to support dialogic interactivity. It examined how they built a dialogic pedagogy that actively develops and extends learners' contributions, so that they jointly construct knowledge. The aim of this research was to observe pedagogical responses to the affordances of the IWBs, especially in relation to teacher questioning and teacher organisation of the thinking dialogues. The three teachers involved in one primary school were observed but not part of any training program. The

purpose was to examine the impact, if any, of the IWB affordances on these teachers' dialogues with their students, and any evidence of the IWB contributing to shared cognition across groups of students.

IWBs have features that are potentially different from a standard classroom display and knowledge sharing facilities. The 'potentially' needs to be there because there are many studies that point out that the IWB can easily be used exactly like the older technologies such as screens and conventional whiteboards (eg Moss et al, 2007, Higgins et al, 2005). The IWB does, however, have the potential affordances of enabling shared thinking across groups; interactive motion; audio feedback; and animated feedback among others.

Three teachers participated, from Prep (year 0), year 3 and year 6. They were identified and selected by the school as 'accomplished' practitioners. They were recognised for the quality of their interactions with students, and as regular and confident users of IWBs. In two cases the teachers had more than six years experience of teaching, and one teacher was a new graduate with an outstanding reputation from her two-year postgraduate Master of Education course. The researchers observed three lessons with each teacher, filming the lessons and coding all the uses of the IWBs.

Data collection was conducted in as naturalistic manner as possible. Filming took place discretely at the rear of each classroom. Teachers volunteered the lessons they wished to have filmed. Teachers were not trained or tutored in any way, and no alterations to the timetable schedule occurred. The researchers fitted around the needs of the teachers. This not to ignore the fact that any intrusion, like a camera and researcher, into the complex system that is a classroom, is likely to have some impact on the learning environment.

Teachers had freedom to choose the lesson topic, interestingly, the bulk of the observed lessons, were in mathematics. Each teacher was briefly interviewed before each lesson to establish the goals for the lesson. Each video film was then edited to isolate occasions on which interactive dialogue of various sorts occurred. A little later, but always less than 7 days, each teacher undertook a video-stimulated interview using the edited film, and was asked to comment on and explain the actions observed.

The interviews were then analysed to focus on all the areas where the teachers were able to articulate that learning was happening due to the sharing of knowledge and where meaningful dialogue and questioning arose from the work with the IWB.

3. RESULTS

The outcomes of this project derive from the observations of, and interviews with, three expert teachers. The data collected was extensive and too complex to fully report here. This report concentrates on points of intersection between teacher questioning and the IWB, and the IWB intersections with the students, and evidence of shared cognition by the students.

The teacher reported on in detail here is a graduate teacher, teaching grade four, and she has selected a mathematics lesson. The lesson focused on moving from angles as objects to measuring of angles of rotation. This teacher was in her first year of teaching, having completed a two-year post-graduate Masters program. In this initial teaching course she had excelled and observations in her classroom belied her inexperience. The mathematics lesson being used for the case study was introducing the use of the protractor and the concept of measurement of angles.

Here the transcripts provide a sense of the lesson structure. The following transcript comes from excerpts from video recording. The teacher commences the lesson by raising a protractor.

Teacher: Today we are going to be using this. What is a protractor used for? Tell me? Pretend you are explaining what the protractor is to someone who has absolutely no idea.

Student C: Angles

Teacher: Angles? What do you mean by angles? I understand what an angle is. So a protractor has something to do with angles. Let's use a full sentence to describe what it might do. (**Student N**) do want to have a go and build on (**Student C's**)

Student N: I've got two things. One, you can get it on a computer and two; it's to show the degrees of the angle.

Teacher: Beautiful, so you're measuring the degrees of that angle okay?

Now the teacher focuses on the IWB where she has an angle drawn.

Teacher: Can someone please draw for me where the angle actually is on this diagram?

Teacher makes time to establish the specific ideas that she wants the children to consider and share. She has used the IWB as a conventional board. The angle could have been on any board, and most of the interaction has been verbal. At this point comes a dramatic turn in the lesson. Next the teacher brings up a very large moveable protractor on the IWB while **Student S** volunteers to come up to the board. The teacher now moves to one side away from the board, and only rarely returns to it for the remainder of the lesson.

Teacher: So that is what we're actually measuring. Now I have this protractor but I have no idea how to use it. Has anyone used a protractor before? Ah, so we have a few experts in here. Let's see if we can share our knowledge. If I was to measure this angle where do I put the protractor? Who knows?

Student M: On the bottom line and next to the point

The teacher has focused on the IWB now showing a projected large protractor that she can move around the screen. She now inquires from the students and asks them:

Teacher: What do I do? Put the two points together, but there are two sets of numbers here and I'm really struggling to know why two sets of numbers, and which ones are I use.

Gesturing she now points to some of the children inviting them to, Have a guess, have a guess, I don't know.

The teacher has taken up a storyline, of 'not knowing' and she is questioning the students, prompting their thinking and asking what it is she needs to do. She has used the pronoun '**I**' signaling to the children she is the one who needs help (Redman & Fawns, 2010). She has positioned them as helpers, saying '**we** have a few experts in here', and explicitly asked for sharing cognition from them, '**we** can share our knowledge'.

After the lesson the teacher is reviewing the video and she is responding to questions in a conversational style approach. Here she is reviewing **Video Clip**. The teacher is pretending that she doesn't know how to use the protractor to measure an angle and asks the children.

Interviewer: Just unpack that for me again what you did there to make them...

Teacher: Just in terms of me playing dumb?

Interviewer: That particular one why do you play dumb there?

Teacher: Just because I feel like that it's something that they can come to themselves. They've seen what protractor looks like. Ideally in this situation it would be good if they could have all had their own protractor in their hands, and then they could see the structure of it and make the own conclusions from using it. Because well its not obvious but you could come to the conclusion that that's where you've got to put the point because it's the intersections of the lines, so it's a way for them to come to that understanding themselves, but also the sharing In terms of the collaboration. Those ones that are experienced with the protractor can share their knowledge and the others can use that time to really build up their knowledge.

After explaining that she seeks for her students to support and assist each, now she reviews the in-class **Video Clip** recording. It shows her using IWB to investigate where to place the protractor on the surface.

Interviewer: So you have now started to make the board support your question. What happens now?

Teacher: They look at the common reference point on the board they have established that it needs to line up with the middle….

Interviewer: What is the board doing at the moment?

Teacher: It is the common reference point. So it's acting as a collaborative effort, measuring this particular angle. The kids feel like they can infer that you mention the angles using the numbers and then from here I think with my questioning I specifically lead them to the point where they realize that they have to line up the zero with the line so you can measure the angle from zero, and so they're sort of going through that process themselves.

This graduate teacher is explicitly stating how she is working with the board, she states it is acting as a collaborator, and she has the control, she leads with her questioning, she uses the board as central point of reference.

4. DISCUSSION

The teacher, while maintaining a flow of probing questions, withdraws to the side, and provokes the children to articulate their ideas by reference to the IWB. She more than once uses the device of pretending to know nothing in order to place the children at the forefront, allowing them to both refer to and to come up to IWB

to share their insights with the whole class. She claims that the IWB is 'the common reference point' which provokes collaborative development of understanding.

As the lesson develops by using the animated protractor to build an understanding of why there are two 180-degree scales, and finally measuring, the teacher repeats these processes. Sometimes she plays ignorant, sometimes she invites specific children to verbalize what they are seeing on the IWB and to share their insights with the class, and occasionally she steps in to assume control herself.

In her **Video Clip,** the graduate teacher uses the very large protractor and introduces the problem of reading the scale into opposite directions.

Teacher: It's quite difficult trying to teach them the protractor without having that sheer size on the board.

Interviewer: Why is it important that they can see it easily?

Teacher: Because I want them to understand that if they don't line it up with the zero, then it's very difficult to calculate how many degrees in between but if they lined up with the zero they can easily see how many degrees it is from there. So it's reinforcing the fact that they have to have it lined up from zero.

In the **Video Clip** the graduate teacher asks how do we know whether we're going to look at the less than 90 scale or the larger than 90 scale for a specific angle. Student A answers that it depends on whether the angle is acute or not.

Interviewer: So what did you do then with him?

Teacher: The vocabulary. So it's fantastic when they can use the vocabulary. It's connecting the factors between the words. So that's a big step for him. In terms of the start of the year, he really couldn't even form a cohesive sentence. To deal with these … and it's quite a challenging concept, bringing back that vocabulary from previous lessons and then that's the starting off point for this sequence of questioning as it really connects those things.

Interviewer: Do you think with a child, like student A, there is a sense that the visual is actually helping send to long-term memory?

Teacher: I honestly don't think this lesson would have been possible without the interactive whiteboard. Because it's a very difficult thing to collaboratively focus upon (a real protractor) because it is physically so small and I think this visual of having this angle - and he can see from our previous lessons that that's an acute, a right or an obtuse angle, and he's making that connection with the visual.

Video Clip. In this section of video film where teacher uses the visual large protractor on the screen to illustrate the crucial importance of knowing whether we're working with an acute or obtuse angle and clarifying the language for those who are struggling.

Interviewer: So you are drawing and creating angles and stressing the two scales. Why do you have to do that?

Teacher: I think just to make it explicit for them. Also in terms of like their levels of thinking. It has gone from the sort of basic levels that, if you're looking at Bloom, like the understanding and the making the connections to the applying and then we're going onto the creating and we will be looking at that further. It's just about them understanding visually those connections that they have already made verbally but then reinforcing that.

The **Video Clip** shows the teacher-supporting student T, who is struggling, as a model for developing an idea of how to measure the angle on the interactive whiteboard.

Interviewer: Can you unpack that section because that was quite a lot of questioning?

Teacher: He is a bit of a struggler in terms of grasping concepts, so it was good for him to be able to go through that process, but in terms of like looking at which set of numbers to choose it was about him beginning to realize and making connections to-like past lessons and knowledge that he already had, and then making new connections to what he is looking at the moment. So in terms of him looking at the top numbers we went back to basics and looking at whether it was bigger or smaller than the right angle, and then going through the process of discovering - okay we have to look at this set of numbers - and I think that process to him would have been a very similar situation for quite a few of the kids in the class, going through the process… that step by step, and then essentially thinking that maybe I can ask myself these questions while I am doing it. So it's giving them ideas almost like a checklist - what they need to go through.

Next the **Video Clip** is about Student A being asked to verbalize this thinking every step of the way.

Teacher: So he has that very particular need to verbalize. So depending on the individual needs of the kids I will really ask them to do different things.

Interviewer: And he does it very well - why do you think he does it very well?

Teacher: Because there's been a lot of lead up and also the previous questioning could have helped him as well.

In this lesson, the IWB is being used, and has become a visual means of inviting the children to share their insights. The teacher is insistent that correct language is a key part of the understanding and of sharing the concepts, she promotes actively the correct mathematical language. She glories in the achievements of the children when their use of the vocabulary indicates their own absorption of the concepts in relating previous understanding of the static views of angles as 'acute', 'obtuse' and 'right' to the new dynamic concept of measuring angles of rotation. She actively encourages students to verbalize these ideas to their peers. In this whole section, the teacher is barely seen on the lesson video because she has handed much of the thinking and verbalizing to the students.

Near the end, as she uses the interactive features to make and measure rotations, she chooses a student who normally struggles, to unpack the process of measuring step by step. This was possible because the child could speak about each action as he activated the animation on the IWB. The teacher claims that the choice of this student was deliberate so that that process to him would have been a very similar situation for quite a few of the kids in the class, going through the process… that step by step and then essentially thinking 'maybe I can ask myself these questions while I am doing it'. So it's giving them ideas almost like a checklist, what they need to go through. She claims she can use such students as models because of the support given by the IWB affordances. The sharing with the class through the IWB then aids the rest of the class to clarify their understanding.

5. CONCLUSIONS

There have been numerous studies lamenting that IWBs have failed to produce the educational change and improvements in pedagogy that were expected or hoped for in the first decade of the 21st century. The case studies described here are suggesting that important pedagogical change can occur under certain circumstances. In particular, it can occur, and is likely to occur, if the teachers already incorporate sharing of ideas, creating time to think in dialogue, high level questioning and thinking, and recognition of the importance of children owning and sharing their own learning into their teaching

Analyzing the pedagogical changes that were observed, it is clear that many of them fall into the category of dialogic interaction, and thus re-enforce the work of Hennessy. In this study all three teachers stood back from the board and invited their student to verbalize while access to the boards has produced regular examples of shared cognition, where the insight of a student supports the learning of peers. All three teachers constantly ask particular children to model ideas while interacting with the IWB, and all claim they choose each child for two purposes: to help the child who is modeling by verbalizing ideas; and to share this with the rest of the class, in the belief that children can often explain better to peers than the teacher if they have the visual and interactive support of the IWB.

All three teachers used IWBs to provide waiting time for children to think and verbalize. To most teachers this is a difficult area. Waiting time gives opportunity for other children to move off-task. All three observed teachers here deliberately used the visual and interactive affordances of the boards to focus and engage the class, giving the child doing the modeling, time to think and verbalize. This was seen when student T needed time to explain about an aspect of the number on the protractor, and the teacher explains their pedagogical thinking:

> He is a bit of a struggler in terms of grasping, concepts so it was good for him to be able to go through that process, and I think that process to him would have been a very similar situation for quite a few of the kids in the class, going through the process… that step by step…When students have time like this, not only can they order their thinking, but they can more effectively share it.

All these teachers deliberately absented themselves from the IWB. Each teacher ensured students felt they had command over the board as the teachers stood to one side. This appears to be allied to these teacher beliefs that children must own and share the learning that is taking place, and there was a reluctance to dominate, and a deliberate signaling that the child controlled that learning moment.

It was clear from the observed lessons that all three teachers were skilled questioners. All three used the IWB visuals to support open-ended and thinking-rich questioning. However, while IWBs appear to make conditions for higher-level questions easier, it is almost certain these three "expert" teachers would use

higher level questioning under any teaching conditions. Whenever teachers asked a child to describe or explain a set of steps in a process of measuring angles, a quiet 'why' was heard as teachers gently interjected.

So maybe we have been asking the wrong questions. Instead of asking, "what can the special affordances of IWBs *do* to change teaching?" perhaps the question is "what can teachers do to adapt the IWBs for the enhancement of good teaching practice?". By focusing on the natural practices of expert teachers when they come into contact with a teaching medium that includes powerful multimedia, a screen large enough to be accessible to all students, and interactivity through touch or wireless, we have begun to see in this project many examples of enhanced practice. It is clear that in these case studies, dialogic interaction, advanced questioning, student ownership of learning and recognition of thinking time are part of the teachers' common practice. However, it is equally clear that when teachers already have these practices embedded in their pedagogical armory, they have absorbed the special affordances of the interactive whiteboards into their teaching to greatly enhance their teaching effectiveness.

It is significant that the teachers observed were not necessarily experienced. One was a first year probationer. The reason why these three teachers successfully integrated the IWB affordances into their teaching did not appear to be connected with experience or age, but rather their willingness to develop an environment of shared cognition, deep thinking and high level questioning. It is worth revisiting Salomon, Perkins and Globerson's 1991 proposals that working in partnership with machines can redefine and enhance performance. Salomon asks us to consider that perhaps "it is not technology alone affecting minds, but the whole 'cloud of correlated variables' technology, activity, goal setting, teacher's role, culture–exerting the combined attempt".

What this project has observed is indeed precisely that, redefining and enhancement is arising from the cloud of correlated variables. It is not, therefore sensible to expect IWBs to transform teaching. The teaching comes first. If teachers have the expert pedagogies, IWBs, then the successive waves of current and future educational technologies will be successfully incorporated into their growth as teachers and student growth as learners. The first year graduate teacher, from the Melbourne Graduate School of Education, at the University of Melbourne, has been educated in the Master of Teaching model that develops a practice of clinical teaching. The clinical teacher aims 'to be constantly evaluating a student's learning and progress and intervening in specific, targeted ways that are clearly underpinned by research and theory' (Redman, 2014). In conversational style classroom interactions, this young teacher was constantly diagnosing, responding and intervening, working towards increasing student understandings. She combines her research-based understanding of the difficulties students have in this topic, with her knowledge of her students as learners, and utilises the IWBs' affordances to construct active empowering moments of shared cognition.

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REFERENCES

Alvarez, C., Salavati, S., Nussbaum, M. & Milrad, M. (2013) Collboard: Fostering new media literacies in the classroom through collaborative problem solving supported by digital pens and interactive whiteboards. *Computers and Education*, 63 pp. 368-379.

Beauchamp, G. (2011). Interactivity and ICT in the primary school: categories of learner interactions with and without ICT. *Technology, Pedagogy and Education* 20 (2) pp. 175-190.

Chandler, P., & Redman, C. (2012). Teaching Teachers for the Future: Modelling and exploring immersive personal learning networks. *Australian Educational Computing*, 27(3), pp. 54-62.

Delaney, S., Trapani, F., Chandler, P. and Redman, C. (2014). Contemporary practices of technology and its affordances: Perceptions of pre-service teachers on the utilization of technology in teaching and learning practice, Paper presented at the *EDULearn2014* conference, Barcelona,

Hennessy, S., Deaney, R., Ruthven, K. & Winterbottom, M. (2007). Pedagogical strategies for using the interactive whiteboard to foster participation in learning science. *Learning, Media and Technology*, 32 (3) pp. 283-301.

Hennessy, S., Warwick, P. & Mercer, N. (2014). *Using the IWB to support classroom dialogue*. Faculty of Education, University of Cambridge. http://dialogueiwb.educ.cam.ac.uk/ Accessed February 9th 2014.

Luckin, R. (2008) The learner centric ecology of resources: A framework for using technology to scaffold learning. *Computers and Education* 50 pp. 449-462.

Mercer, N. (2010). *Foreward* in M. Thomas and E. Cutrim Schmid (Eds.), Interactive Whiteboards, theory, research and practice. Pp. xv-xvi. Hershey, PA.

Mercer, N., Hennessy, S. & Warwick, P. (2010). Using interactive whiteboards to orchestrate classroom dialogue. *Technology, Pedagogy and Education* 19 (2) pp. 195-209.

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

Osborne, J. & Hennessy, S. (2003). *Literature review in science education and the role of ICT: Promise, problems and future directions*, Bristol: Nesta Future Lab.

Perkins, D. (1993). *Person-plus: a distributed view of thinking and learning*. In G. Salomon (Ed.), Distributed cognitions pp. 88-110. Cambridge, England: Cambridge University Press.

Redman, C. (2010). *How to use pronoun grammar analysis as a methodological tool for understanding the dynamic lived space of people*. In S. Rodrigues (Ed), Using Analytical Frameworks for Classroom Research, Routledge, New York, pp. 163-182.

Redman, C. (2014). (IN PRESS), The Melbourne Graduate School of Education – Master of Teaching model, In J. Ryan and M. Jones (Eds), *Partnerships, Reflective Practice and the Place of Technology*, Sense Publishers, The Netherlands.

Rudd, T., (2007). *Interactive whiteboards in the classroom.* Futurelab, UK. http://archive.futurelab.org.uk/resources/documents/other/whiteboards_report.pdf Accessed February 9th 2014.

Salomon, G., Perkins, D. & Globerson, T. (1991). Partners in cognition: Extending human intelligence with intelligent technologies. Educational Researcher, 20 (3) pp. 2-9.

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) pp. 443-457).

Sweeney, T. (2008). Transforming learning with interactive whiteboards: Towards a developmental framework. *Australian Educational Computing* 23 (2) pp. 24-31.

Tanner, H., Jones, S., Kennewell, S. & Beauchamp, G. (2005). *Interactive Whole Class Teaching and Interactive White Boards*. Proceedings 28th MERGA conference, Melbourne Australia pp. 720-727.

Vincent, J. & Jones A. (2008). Using models for understanding pedagogical change in a technology environment: A case study of IWB implementation in a secondary school. *Australian Educational Computing*, 23 (2) pp. 32-37.

Wall, K., Higgins, S. & Smith, H. (2005). 'The visual helps me understand the complicated things': pupil views of teaching and learning with interactive whiteboards. *British Journal of Educational Technology*, 36 (5) pp. 851-867.

Warwick, P., & Kershner, R. (2008). Primary teachers' understanding of the interactive whiteboard as a tool for children's collaborative learning and knowledge building. *Learning, Media and Technology*, 33 (4) pp. 269-287.