Accepted for publication in Computers and Education, 2010. Please do not cite without permission.

In the mind and in the technology: the vicarious presence of the teacher in pupil's learning of science in collaborative group activity at the interactive whiteboard

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Abstract

The focus of research into the use of the interactive whiteboard (IWB) in the classroom has been largely in relation to teacher-pupil interaction, with very little consideration of its possible use as a tool for pupils' collaborative endeavour. This paper is based upon an ESRC funded project[1], which considers how pupils use the Interactive Whiteboard (IWB) when working together on science-related activities. It provides an analysis of video and other data from science lessons in UK Year 4 and Year 5 primary classrooms (pupils aged 8-10 years). Concentrating on a series of lessons constructed by three (out of twelve) of the project teachers, together with their written and spoken commentaries, it takes each set of lessons as a case for study and comparison.

This paper focuses in particular on the nature of the 'vicarious presence' of the teacher evident in the group interactions at the board. We address the following questions: How is the teacher's vicarious presence evident in the work of pupils at the interactive whiteboard? How does this presence influence the behaviour of pupils engaged in science activities?

In this account, we suggest that the teacher remotely mediates the activity of the pupils at the board in two specific and interlinked ways. Firstly, the vicarious presence of the teacher seems to be in the minds of pupils, enabling them to appropriate and use introduced rules and procedures, in this case in relation to group talk. Secondly, it is in the ways in which the constructed task environment on the IWB guides and mediates the pupils' actions, enabling them to connect with, interpret and act upon the teacher intentions for the task. Here, the teacher's vicarious presence is in the technology.

We conclude that the IWB *can* provide both a tool and an environment that can encourage the creation of a shared dialogic space within which co-constructed knowledge building can take place. However, this only occurs where there is active support from the teacher for collaborative, dialogic activity in the classroom and where the teacher is able to devise tasks that use board affordances to promote active learning and pupil agency.

Keywords: cooperative/collaborative learning; elementary education; *interactive learning environments*

[1] ESRC project RES-000-22-2556

1. Introduction

Interactive Whiteboard (IWB) systems comprise a computer linked to a data projector and a large touch-sensitive electronic board displaying the projected image. Children or teachers can manipulate objects on the screen directly by hand or with a stylus. Each model comes with dedicated software, but might also be considered as a digital hub through which other technologies can be channelled, as orchestrated by the teacher and the children. In our research, teachers and pupils used the standard Notebook (Smart) and ActivPrimary (Promethean) software that is central to IWB functionality, together with the integration of internet or hardware resources.

The extensive introduction of interactive whiteboards systems into UK primary classrooms in recent years has been encouraged by policy initiatives and the provision of substantial financial resource (Glover, Miller, Averis, & Door, 2005; Higgins, Beauchamp, & Miller, 2007; Higgins, Falzon, Hall, Moseley, Smith, Smith & Wall, 2005; Moss, Jewitt, Levačić, Armstrong, Cardini, & Castle, 2007). The result is that, in many UK primary, IWBs have almost completely replaced other classroom equipment such as ‘ordinary’ whiteboards and are in daily use by teachers and pupils.

It seems clear that many teachers have found IWBs to be an important and highly motivating teaching resource (Rudd, 2007; Warwick & Kershner, 2008). Studies have indicated some positive developments in whole-class teacher-led sessions, including teachers’ engagement with surface features of interactive teaching (Esarte-Sarries & Paterson, 2003; Higgins et al., 2005; Smith, Hardman, & Higgins, 2006). Indeed, the embedded use of the IWB in teaching and learning has been evidenced in some studies as a ‘major factor that leads to attainment gains’ in literacy and numeracy in UK classrooms (Somekh, Haldane, Jones, Lewin, Steadman, Scrimshaw, Sing, Bird, Cummings, Downing, Harber Stuart, Jarvis, Mavers, & Woodrow, 2007, p.6). Despite these positives, however, it is clear that IWBs have often been made to fit pre-existing instructional practices (Nordkvelle & Olsen, 2005) and that students may, ironically, feel themselves excluded from the use of this ‘interactive’ resource (Wall, Higgins, & Smith, 2005). This is unsurprising, as the introduction of new technologies has not usually been accompanied by an adequate understanding of what their take-up might imply for pedagogy (Hennessy, 2006; Wellington, 2005).

However, it is clear that - after a period where the technology has become embedded in classrooms - many teachers are looking at the potential of the IWB as more than a ‘teacher resource box’(Warwick & Kershner, 2008). In an environment where there is a clear policy concern with the development of collaborative classroom learning environments (DCSF, 2008; DfES, 2004), many primary teachers in the UK are developing their commitment to ‘…active, self-regulated and collaborative learning’ (Hennessy, 2006), in part by considering how the IWB is used by students in their classrooms.

The research reported here considers how teachers integrated pupils’ semi-autonomous use of the IWB into their science lessons. In so doing we consider the direct involvement of the teacher with pupil groups; however, the central focus of this paper is the nature of the ‘vicarious presence’ of the teacher evident in the group interactions at the board. In examining this vicarious presence, we suggest that the teacher remotely mediates the activity of the pupils at the board in two specific and interlinked ways. The first of these is concerned with the ways in which the pupils appropriate and use introduced rules and procedures – in this case in relation to group talk. In our research classrooms, the emphasis on classroom rules for talk seems to create, in the minds of pupils working in groups at the IWB, a collective sense of appropriate ways in which to conduct learning conversations. We observed them working with these rules, interpreting them for the needs of their situation at the IWB, implicitly and explicitly remembering the emphasis placed upon them by the teacher. Prior to full internalization of this support structure - and the confident, autonomous use of exploratory talk in group settings - they were learning to become learners of the sort that seems to be expected by the teacher. Importantly, we suggest that it is the collective, distributed awareness of this vicarious presence of the teacher in the minds of the pupils that enables groups to operate effectively, collectively mediating one another’s behaviour.

The second way in which the vicarious presence of the teacher is evident in our research classrooms is in the ways in which the teacher uses the task structure to guide and mediate the pupils’ actions, enabling them to interpret and act upon the teacher’s intentions for the task. Much research in this area has focused on the mediational effects ascribed to ICT tools in the context of computer-supported collaborative learning, where software is usually specifically designed to guide and mediate collaborative learning at the computer in particular ways (for example, see Linn & Slotta’s Web-based Inquiry Science Environment (WISE), 2000; Looi, Chen, & Ng’s work on GroupScribbles, 2009).

By contrast, we report on a use of technology where the standard IWB interface affords the creation of teacher constructed environments that can ‘serve in a face-to-face event as a referential anchor, coordinate joint attention and interaction, be an object for manipulation, and thus, support collaboration’ (Arvaja, Häkkinen, Kankaanranta, 2009, p.270). Here, the teacher’s vicarious presence is evident in the technology. Using the standard software on the IWB, and the occasional integration of internet or hardware resources, the teachers in our research classrooms devised learning activities that might serve to mediate the pupils’ collaborative interaction and learning. They were thus using technological tools that are not designed *specifically* to support collaboration, but which rather presented possibilities to teachers and pupils for developing science learning. This is important, as we hoped to see how teachers might express the functionality of the standard IWB software as affordances for collaborative learning in their science lessons, scaffolding activities through the structure of particular activities and through the ways in which they effected interactivity within and between IWB pages.

We consider these twin manifestations of the teacher’s vicarious presence below, but it is first useful to consider the context in which these considerations arose.

2. The research in context

Our research findings derive from an ESRC-funded project[2] that investigated the potential of the IWB as a resource for assisting collective thinking and learning in the study of science. Focusing on children's learning in the context of their semi-autonomous, collaborative use of the IWB during science curriculum activities, the overarching exploratory research question was 'How do children use the IWB when working together on science-related activities?' The study particularly focused on exploring the distinctive role of the IWB for supporting and contextualising productive dialogue and other forms of interaction amongst students in collaborative science activities in the primary classroom, and on examining how students use the IWB to share relevant ideas and create new joint understanding in science activity.

As indicated above, in focusing on students' collaborative use of the IWB for learning we categorically do not wish to imply that the teacher is absent from the process. Previous research on computer use in the classroom has pointed to the link between the teacher's role in supporting children's learning through task design and intervention, the ways in which knowledge is interactively developed and represented, and the children's involvement in collaborative classroom practices which emphasize shared cognition and a re-working of pupils' own ideas (Dawes, 2004; Hennessy, Deaney, Ruthven, & Winterbottom, 2007; Wegerif & Dawes, 2004; Wegerif, Mercer, & Dawes, 1998). As Rudd (2007, p.6) argues, a '… central issue appears to be how teachers become critical agents in mediating the technology to provide a more dynamic, interactive and appropriate learning experience'. This is the central concern of this paper, which details how the teacher's vicarious presence of the teacher is evident in three case studies taken from the research data.

In considering these case studies, it seems evident to us that teachers' own thinking about learning is of fundamental importance in this mediation of students' collaborative learning experiences with technology, and in the use of technology in the classroom per se. For this reason the research was constructed with reference to an earlier project (Warwick & Kershner, 2008), exploiting established links between the University of Cambridge Faculty of Education and Cambridgeshire Local Authority (LA) ICT Support and Advisory Service. Twelve primary teachers in six schools - all teaching children aged 8 to10 years (Years 4 & 5 in UK primary schools) - participated in a guided research group (John & Sutherland, 2005; Noffke & Somekh, 2005). The work with the teachers was carried out over nine months and was designed to involve all stakeholders in the project in layers of reflective interaction and analysis.

In the research group - comprising 4 university researchers and 12 teachers - theoretical perspectives on learning were explored. Consideration was given to the role of productive interaction in groups and how this might link to joint, purposeful science activities in which knowledge can both be deployed and co-constructed (Wertsch and Tulviste, 1998). The focus of much discussion in the research group was on ways in which classroom talk might be extended and developed during pupil group activity (Mercer, Dawes, Wegerif, & Sams, 2004; Mercer & Littleton, 2007; Mercer & Sams, 2006). The discussions were based on a shared perspective within the group that '...classroom talk...is the most important educational tool for guiding the development of understanding and for jointly

[2] ESRC project RG49888

constructing knowledge.' (Mercer & Hodgkinson, 2008). These discussions were also predicated on the idea that the IWB might provide a ‘dialogic space’ for children to jointly consider information and task requirements, to plan their responses and debate options before making joint decisions (Wegerif, 2007, 2008); in other words, to actively participate in the co-construction of science knowledge.

Sharing the teacher development outcomes of the Nuffield ‘Thinking Together’ project (Dawes, 2008a) enabled later classroom work to be initiated by the teachers, in which ground rules for ‘exploratory talk’ were explored and established (Dawes, 2008b). We will interpret ‘exploratory talk’ (Mercer, 2000) here as being talk in which:

- all relevant information is shared
- all members of the group are invited to contribute to the discussion
- opinions and ideas are respected and considered
- everyone is asked to make their reasons clear
- challenges and alternatives are made explicit and a negotiated
- the group seeks to reach agreement before taking a decision or acting.

In addition to the exploration of such perspectives, time was spent in the research group considering the ways in which ‘expert’ IWB users created purposeful learning activities in science. The intention here was not to demonstrate ‘templates’ for science activities, but rather to show how different teachers had perceived the various functions of the IWB as affordances for science learning (Hennessy et al., 2007; Jewitt, Moss, & Cardini, 2007; Kress, Jewitt, Ogborn, & Tsatsarelis, 2001) and to open up the discussion of possible links between the use of the technology and the learning intentions of the research lessons. Just how the teacher mediates technological tools for learning depends on many factors (Cogill, 2003; Hennessy, 2006) and perhaps one of the most important is how the teacher perceives the affordances of the tool for the activity in question – that is, what it is seen to offer to the people involved (teachers and pupils) in relation to their immediate and longer-term learning intentions and needs. The apparent affordances of a new tool only become actual affordances if they are perceived as such by those using the tool and, importantly, the affordances perceived by the teacher seem to relate directly to their pedagogic understandings and intentions (John & Sutherland, 2005). We shall return to this point in considering the vicarious presence of the teacher in the pupils’ activity at the IWB.

2.1 Methods and research questions

Each of the research teachers devised 3 science lessons based on their on-going schemes of work. One lesson was intended as an independent pilot and could be related to any ‘free-standing’ area of science, whilst the two ‘research lessons’ were linked in each class, with their theme again decided upon by each teacher in the context of their medium term planning. Thus, 36 lessons in all were planned and observed. Part of the planning for each lesson was the devising of activities that would be appropriate for use by at least one group working semi-autonomously group at the IWB during the lesson. Ten of the teachers used Smartboards and two used Promethean boards; each provides a blank screen onto which various objects and text can be placed, either by the teacher or the pupils, together with access to a range of features providing functionality that seem to have 'the potential to support…a more participatory pedagogy' (Kennewell & Beauchamp, 2007).

Data gathered consisted of observational data (digital video-recordings and observational notes of the lessons in each classroom) complemented by records of pupils' work, background information about the curricular content and classroom routines, and pupil interview data. The observational data was analysed using sociocultural discourse analysis (Mercer, 2005) combined with a consideration of how aspects of non-verbal interaction such as gaze, gesture and the manipulation of images and text on the IWB enabled the pupils to use IWB for sharing experience and generating 'common knowledge'(Edwards & Mercer, 1990). For the development of common knowledge within the research group itself, both the teachers and the university researchers took part in an iterative process of selecting episodes of interest from the lesson videos and reviewing these, gradually building a sense of their meaning (Armstrong et al., 2005; Hennessy & Deaney, 2009). As with an earlier pilot project (Warwick & Kershner, 2008), we wished to avoid making unsupported claims about direct learning gains from IWB use and so focused on gathering evidence about the apparent relationship of IWB use to processes that are known to be strongly associated with children's learning and knowledge building, such as certain types of talk and collaboration taking place over time (Mercer & Littleton, 2007; Wegerif & Dawes, 2004). This accords with our interest in the notion of the concept of a 'dialogic space' as crucial to the process of collective knowledge building.

For the purposes of this paper the focus has, as suggested above, been narrowed still further. Using analysis of lessons from three teachers, together with their own written and spoken commentaries, we attempt to address the following questions:

> How is the teacher's vicarious presence evident in the work of pupils at the interactive whiteboard?
> How does this presence influence the behaviour of pupils engaged in science activities?

Each set of 3 lessons for these teachers (1 pilot and 2 research lessons) is taken as a case for study, since they exemplify three slightly different approaches to the use of the perceived affordances of the IWB. These lessons also provide a strong illustration of an intense focus, in these classes, on the establishment and use of ground rules for talk in group activity. (Details for the lessons analysed for this paper appear in the Appendix).

Whilst these lessons are the primary focus of this paper, we also draw on analyses of lessons taught by other teachers in the research group where these serve either to support or to provide alternative perspectives in our discussion. It is worth noting that none of the children had worked with others at the IWB prior to these lessons and they had limited experience of using rules for talk in their classrooms. This is of particular importance in considering the vicarious presence of the teacher, as we are not considering working groups who have fully internalised either ways of interacting in groups or a full understanding of whiteboard functionality and affordance.

3. Research findings and discussion

As stated in the introduction, the indirect mediation of pupil activity at the IWB by the teachers in our research classrooms – their 'vicarious presence' – was evident in two broad but inter-connected ways, influencing the ability of the pupils to act in a semi-autonomous manner in addressing science activities. One aspect of this vicarious presence was in the pupils' apparent appropriation of classroom rules, procedures and established practices. This included whether they demonstrated an understanding of the learning intentions of lesson; their levels of persistence and willingness to accept uncertainty (Osbourne, Ratcliffe, Bartholomew, Collins, & Duschl, 2002); and their motivation and ability to interpret task demands. But in particular it was evident in whether or not they could cooperate and share ideas at the IWB, using questioning, reasoning and discussion to work towards group interpretation and completion of the activities. In other words, whether they held in their minds and were able to apply rules for group talk that had previously been introduced and emphasised by the teacher. We now consider this aspect of the teacher's vicarious presence more closely.

3.1 Group talk and talking about science

Research into pupil collaboration and dialogue in groups suggests that there are numerous elements that contribute to success. This is often assessed in terms of learning gains (Howe & Tolmie, 2003; Howe et al., 2007; Kutnick, Ota, & Berdondini, 2008) or, as there is evidence of 'the strong relationship between elaborated discussion and learning outcomes' (Webb, 2009), by the quality of task-related talk that ensues (Barnes, 2008; Mercer, 1996; Mercer & Littleton, 2007; Mercer & Wegerif, 1999; Reznitskaya, Kuo, Clark, Miller, Jadallah, Anderson & Nguyen-Jahiel, 2009). Both Piagetian and Vygotskian perspectives (Piaget & Inhelder, 1969; Vygotsky, 1962) are helpful in defining why such features as reasoning, justifying ideas, acknowledging and repeating the ideas of others, asking focused questions, working towards agreement and elaborating on ideas seem to be important components of purposeful group interaction (Barron, 2003; Dawes, 2004; Mercer, 1996). In addition, research undertaken by the SPRinG project (Baines, Blatchford, & Chowne, 2007) and associated work in Scotland (Howe, Tolmie, Thurston, Topping, Christie, Livingston, Jessiman & Donaldson, 2007) considers the co-construction of science knowledge in primary classrooms. This work suggests strongly that a consideration of grouping arrangements and the development of 'activities and lessons that develop the use of group work and talk' (Baines, Rubie-Davies, & Blatchford, 2009) not only have a central role to play in promoting positive interactions in pupil groups, but also contribute positively to pupils attainment in science.

In developing pupils as co-learners in group settings (Blatchford, Kutnick, Baines, & Galton, 2003) it is clear that the teacher has a central role to play. The teacher's discourse and actions, particularly their questioning practices (Cazdan, 2001; Galton, Hargreaves, Comber, D. Wall, & Pell, 1999), not only model behaviours for pupils but arguably establish a prevailing learning ethos in the classroom. Even more expressly, where a teacher specifically engages a class in considering how group talk might be developed, this appears to have a direct impact on whether pupils engage in educationally productive talk. In other words, encouraging pupils to be more dialogic in their interactions appears to have considerable learning benefits (Alexander, 2008; Dawes, 2004, 2008b; Mercer, Dawes, Wegerif, & Sams, 2004; Mercer & Littleton, 2007; Mercer & Sams, 2006; Mercer & Wegerif, 1999; Rojas-Drummond & Mercer, 2003; Rojas-Drummond, Pérez, Vélez, Gómez, & Mendoza, 2003; Skidmore, 2006).

In the three classes that are the focus of this paper, the work carried out in the research group on the development of exploratory talk in group settings (Mercer, 2000; Mercer & Wegerif, 1999) was enthusiastically translated into developing classroom practice. Scott, Nina and Catherine all had previously established ‘talk pairs’ in their classrooms and can be characterised as receptive to ideas founded upon socio-cultural views of teaching and learning. They embraced the idea of ‘talk lessons’ (Dawes, 2004, 2008a) and, in the videoed lessons, gave almost equal emphasis to productive talk objectives and to science objectives within the overall learning intentions for the lesson. Significant here is a continuing emphasis on talk rules through whole class discussion; it seems that a support structure is being provided around the negotiated talk rules, with the express intention of developing learners better able to use talk to understand and develop learning in their in collaborative groups (Rojas-Drummond & Mercer, 2003). The following extract from the start of Scott’s lesson on light sources and reflectors is a typical example of the regular re-focusing on talk rules that occurred in all three classes.

> **T:** Now can anyone think to themselves ‘what are the main features of a good group talk?’ What sort of things do I want to hear you doing and saying, whilst you're working and talking as a group? I'll give you just a minute there to talk amongst yourselves, and to see what you can come up with.
> *(The class start to talk in their groups)*
> S1: One person talking at once.
> S2: Yeah one, one person talking at once. People giving their ideas.
> S3: And, and listening to each other.
> S1: Yeah and looking at them.
> S2: And looking at them when they're talking.
> S3: Yeah as that would be quite annoying if they were looking at like say Mr (inaudible).

At the start of Catherine’s lesson on food chains the children have to re-evaluate their ground rules and decide which ones they found most difficult to follow on the previous day, in order that they can focus on that rule for the coming lesson. Catherine asks the children which rule they are going to focus on in this lesson.

> S1: Yeah. Because we sort of all agreed, but we didn't really ask why.
> T: Which ones are you going to do?
> S1: Probably that one.

This re-focusing on talk rules by the teacher, rather than, for example, simply having them on display in the classroom, seemed particularly important to the success of their use by groups at the IWB. It illustrates how regular, direct interventions enable the appropriation of such procedural routines as the use of talk rules and help to establish them in the minds of the pupils.

It is evident from the lesson videos that pupils in all three classes consistently sought ways to express their reasoning in talk and at times in writing on the IWB, usually invoking the rules and conventions that have been negotiated in the class. Certainly, as we have seen above, there was a clear intention by the teachers to scaffold pupil talk and interaction; and the pupils' responses in their groups suggests strong support for Rogoff's (1995, p151) view that sees 'children's active participation itself as being the process by which they gain facility in an activity' – in this case, the activity of using exploratory talk in groups. Thus, throughout the lesson transcripts, there are phrases used that illustrate the pupils' concern with the need to discuss, reason and explain. For example:

- 'So why do we think those first? Why do we think those first?'…

- 'We need to say why as well.'…

- 'No don't, don't write anything yet because we haven't really discussed it.'

Here, the phrase 'need to say' is particularly telling, strongly expressing the idea of the teacher's vicarious presence in the minds of the pupils. A way of talking in groups has not yet been fully internalised – it is not part of an easy and natural way of behaving, the derivations of which are long forgotten. Rather, it is seen to be part of the way in which pupils know – through having negotiated the rules themselves over a series of talk lessons - they can support one another's learning in this circumstance. The vicarious presence of the teacher is invoked to add emphasis to behaviours that the pupils know are central to success in the activity.

Also emphasised by the teachers were the specific links with previous work in science. This temporal connection (Mercer and Littleton, 2007) with other work made clear to the children the focus – conceptual or procedural (Gott & Duggan, 1995; Osbourne et al., 2002; Warwick & Siraj-Blatchford, 2006) – for the coming activity. All of the teachers therefore suggested ways in which the pupils might like to think about the task ahead, focusing on the nature of the science learning associated with the activity but without being directive about expected outcomes.

The central point from the above discussion is that, prior to any work at the IWB, the teachers have established a vicarious presence within the working groups, one that emphasises the importance of particular ways of talking about science and which emphasises key ideas about how 'handle' the concepts and procedures of science that will be encountered in the lesson activities. We would argue that without such mediation – embedding the vicarious presence of the teacher and the messages their presence carries into the minds of the pupil groups - pupils working at the IWB would be less successful in their attempts to collaborate. Indeed, we have examples in our study classrooms where this was exactly the case. Groups interacted less successfully at the IWB when the dialogic space is unsupported or disrupted and this was usually where there was little or no sustained emphasis on how to talk productively in groups.

3.2 The teacher and science learning at the IWB

The second way in which the vicarious presence of the teacher was evident was in the structure and content of the IWB activities – here, the teacher was present in the technology.

In designing ‘texts’ for the IWB for interactions in whole class settings, teachers have been shown to consider (in addition to ways in which design might influence lesson pace) the twin possibilities, or resources, of multimodality and interaction. These have been described, in turn, as ‘the IWB’s capacity to harness a wide… range of multimodal resources in order to facilitate pupil learning’ and ‘its capacity to enhance interactive whole class teaching’ (Jewitt et al., 2007). The need for teachers to consider the appropriate use of such resources points to their ‘critical role…as task designers in shaping the learning experiences of pupils’ when using ICT in the classroom (Yoon, Ho, & Hedberg, 2005). In the research reported here the teachers considered the use of these resources of the IWB and the ways in which they afforded opportunities for learning for pupils working in their groups. They used their knowledge of IWB functionality and its affordances for learning in whole class settings to construct activities that might scaffold or mediate the learning activity for these groups, and in so doing were in fact embedding their vicarious presence into the activities to be undertaken at the IWB.

In some ways this might be seen as the teacher embedding a ‘vicarious consciousness’ (Bruner, 1986) within the IWB that can guide and support the pupils in their activity. This embedding process mirrors some of the features of scaffolding that are applied to teacher intentions and approaches in ‘conventional’ lessons (Tharp & Gallimore, 1988; Wood, Bruner, & Ross, 1976); we will consider this in more detail later. What is important here is that the embedding process is one of the ways that the teacher constructs an environment for learning at the IWB, and that this environment has a particular intention; it is to be at the core of a ‘conversational framework’ (Laurillard, 2004, p.29) between pupils and between pupils and the teacher.

For now, let us reflect on the specifics of what the teachers did to enable engagement in these activities by the pupils working at the IWB.

3.2.1 The ‘external memory’ of the IWB - the use of the page sorter and page hyperlinks to assist learning

Both Nina and Scott designed screens where the page sorter was kept open whilst the pupils worked (Figure 1).

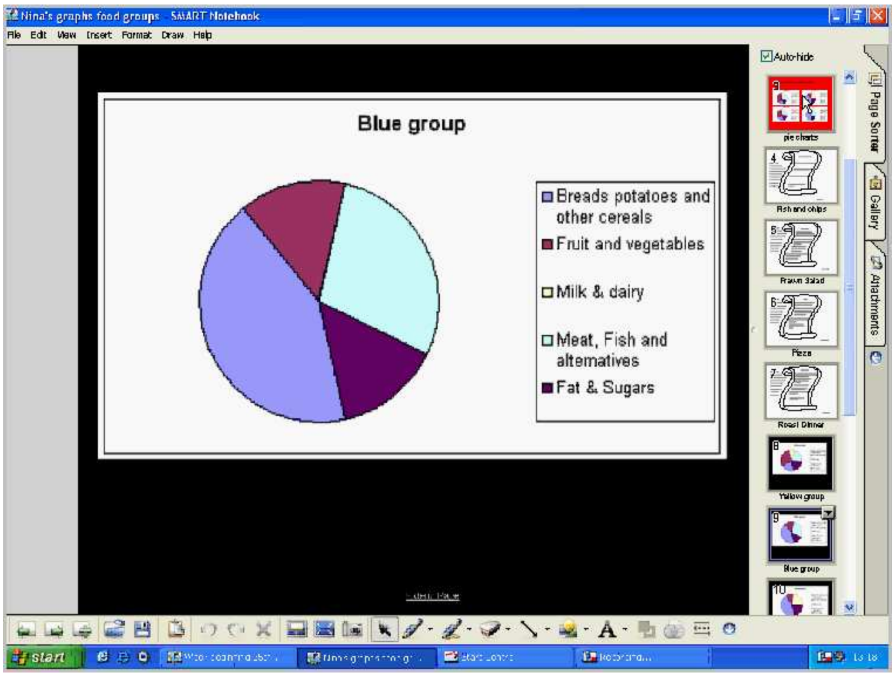

Figure 1: a screenshot from one of Nina's lessons with the page sorter at the right-hand side

These small versions of the pages that comprise the activities for the lesson might be thought of as acting as an external assistive memory to assist the learning of the pupils in both classes – allowing pupils to, as one pupil in Nina's class put it, 'flick back pages in your mind'. Nina's research lesson 1, linking menus with pie charts of food groups, nicely illustrates her approach in all three of her lessons. She had constructed the task so that the pupils were required to cross-reference different hyperlinked screens to establish the relationships between the menu items and the representation of food groups on the pie charts. The following extract of pupil discussion has them moving between linked pages and provides clear evidence that this device, embedded in the structure of the activity by the teacher, enabled the use of page sorter in checking claims made in relation to the data.

S3: The best balanced meal is roast dinner. Because it's more balanced out on the pie charts.
S1: I don't think, hold on.
S3: Yeah roast dinner is yellow group, so yellow group. It's more balanced out
S1: That bit, and that bit, because they're bigger than the rest of them.
S2: Hold on.
S3: That's not balanced out, that.
S1: Could you just um. No it isn't, could you just go back? Because um, that's what (inaudible)
S3: That's not.
S2: Its yellow group.

S3: And that's not
S2: its yellow group.
S1: I think that definitely isn't because of.
S3: The rest aren't balanced out.
S1: That and that and that, and that. That's why I don't think they're balanced out.
S2: What?
S1: They're not balanced out because, because there's more of that, those 3 than there is of them 2.
S2: Yeah but. No that one's bigger than that one. I think. No, no, no, no. Rub it out.
S1: No and that one isn't bigger because of that bit. That one's definitely the biggest. That's definitely not balanced out.
S3: That one's definitely not.
S1: Because of that bit.
S3: And that one's definitely not.
S1: Because of that bit.
S2: See the most balanced is the (inaudible).
S3: Roastie, roastie.

This extract also clearly illustrates the pupils' concern to justify their claims on the basis of the evidence (Osbourne et al., 2002) and shows that this justification and reasoning need not be entirely spoken when the evidence seems to 'speak for itself' – for example, 'That and that and that, and that. That's why I don't think they're balanced out'. However, it is interesting to note that earlier in this lesson, and early in the others carried out in Nina's class that focused on data interpretation, the pupils did not always initially scrutinise the detail contained on each page. Rather, they seemed to focus on the surface features of the screen images and 'latch on' to an erroneous idea, often persuaded by a group member's insistent pointing at the screen combined with a positive statement - 'that one , that will be fats and sugars, that will be the …' (S2 at the start of the task). The passage above shows how the group eventually returns to and challenges this initial idea, reviewing decisions and using the page sorter as a checking mechanism in the light of accumulating evidence, in a manner much more characteristic of the broad approach to data interpretation apparent in pupils of this age (Warwick & Siraj-Blatchford, 2006).

In Scott's class the page sorter was still open but was used rather differently to enable the teacher to sequentially present the task to the students. Again, though differently than in Nina's lessons, the pupils are provided with an external memory affordance, allowing them to easily return to previous pages in a sequence of interconnected activities. Thus, in the pilot lesson on light and reflectors, the pupils returned to a previously completed task to change their original responses on the basis of further thinking:

> S2: 'Can we change something? (*pointing back to previous page*) You know we chose the colour, I don't think it should be blue, I think it should be yellow.'

The pupils had become aware of the interconnectedness of the activities and the external memory of the open page sorter led to a retrospective revision of the group's initial response. Linked to this, the ability to 'look forward' in the page viewer also seems to assist this group, since Scott's lessons in each case lead to a final investigation that pulls ideas from previous activities together in a manner where group knowledge can be applied. A revelatory 'Oh look…' from one pupil as they see something coming up in the page viewer illustrates this nicely at one point in the pilot lesson. This contrasts with some uses of the page viewer by teachers noted by Jewitt et al. (2007), in which moving through prepared screens served to fragment knowledge. Here, the pupils' use of the page sorter enabled them to make connections and move back and forth through the 'story' of the lesson.

In Catherine's class the page sorter was hidden during each of the lessons. Instead, specific objects and pages were hyperlinked for easy cross-referencing, providing a different form of external memory for the group. For example, in research Lesson 2 (food chains) the central task was to create and justify woodland and pond food chains. Each organism on the page) was linked to a 'fact file' that provided some information upon which decisions about positioning within a food chain might be based (Figure 2 – a & b). The vicarious presence of the teacher was very clearly embedded in the affordance for learning offered by this hyperlinking.

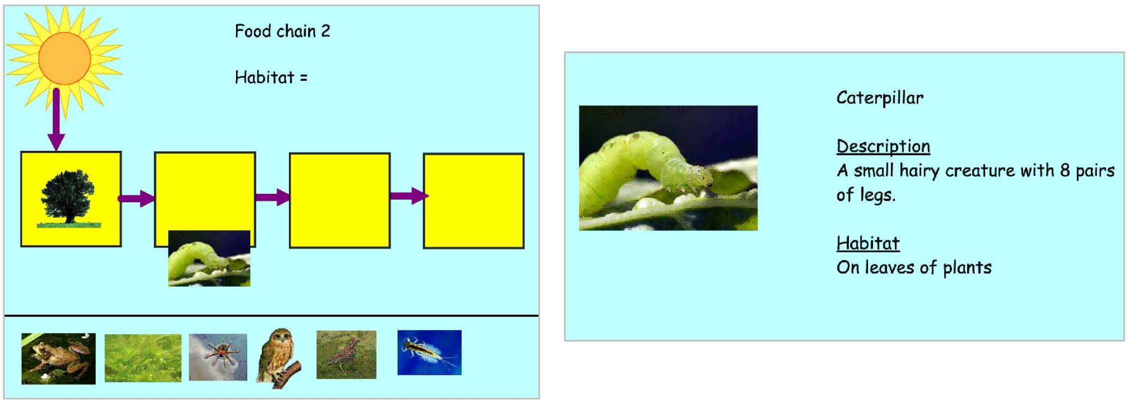

Figure 2(a & b): the food web in used in Catherine's lesson and one of the pages hyperlinked to the organisms on the working page

It is interesting to note that whilst the pupils had no significant technical problems with the hyperlinked pages, and were given specific instructions about how they might use this resource, they chose to use the affordance in a way not envisaged by the teacher; all the pictures of plants and animals were systematically clicked on and the fact files were read before any attempt was made to place the objects in position on a food chain. Thus, the teacher may have viewed this affordances of the board as working in one way, but the children – working semi-autonomously at the IWB – viewed it differently. The 'teacher's constructed environment' (Laurillard, 2004, p.33) provides different possibilities for the pupils than those envisaged by the teacher.

3.2.2 Locking and freeing board objects

The degree of freedom for pupil action within a task at the IWB is partly determined by the ways in which the teacher chooses to lock down or free objects to be moved. Scott, for example, routinely allows the movement of some objects on some of his created screens. At times free movement to any position on the board is enabled – as in the creation of the life cycle of a bean in research Lesson 1 – whilst at other times the task calls for the provision of a template for object placement, as in the initial light source or reflector activity in the pilot lesson. Here the created template for object placement appears to define the range of choices for the pupils (Figure 3), but – as with the example cited above for Catherine's class – the pupils seemed to re-negotiate the task parameters.

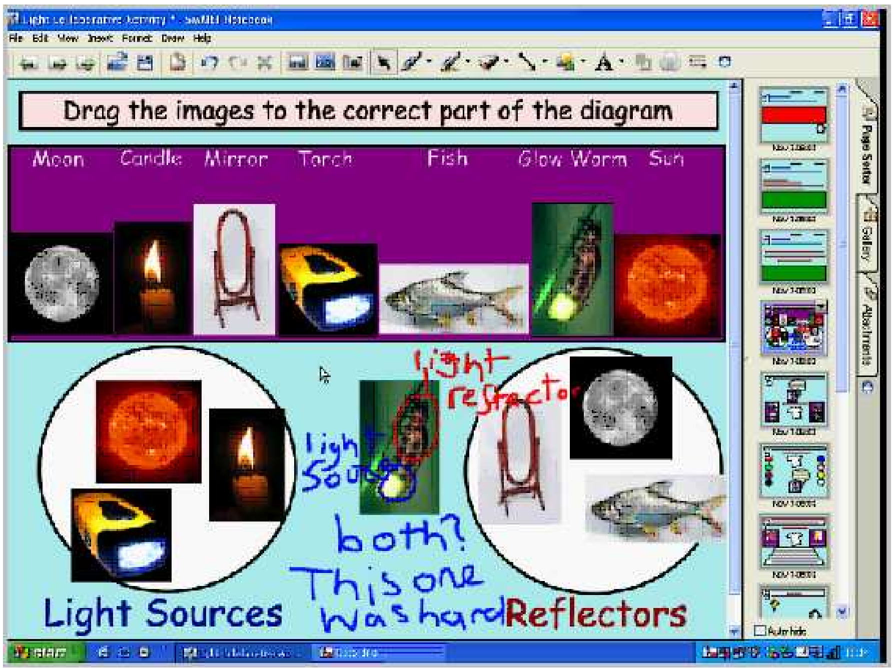

Figure 3: Re-negotiating task parameters in Scott's class

They decided to put the picture of the glow worm in the middle of the two possible groupings to represent their idea that the glow worm may be both a light source and a reflector, thus by-passing the template that the teacher had created. This was further elaborated by pupils who wrote 'both' underneath the picture, indicated that they have created a new category in addition to the two that the teacher had given them. The teacher had not intended this outcome, as he stated in his written reflection on the lesson – 'This was not a response that I expected to see, but it did lead to more discussion surrounding their placement of the glow-worm on the board.' A similar situation occurred in a lesson not selected as one of the cases for this paper, in which children were asked to categorise objects as either solids or liquids and, perceiving an anomaly, chose to place some objects outside the confines of the teacher-created groupings on the IWB.

In Catherine's class, teacher mediation of the task through locking some objects and allowing the movement of others was also evident - for example, organisms move but food chain positions don't (research lesson 2), or animals can be placed in position on an identification key (research lesson 1). The templates for object placement defined the choices for the pupils, in that only one organism fitted in each box and the activities would have made no sense if an organism was placed outside the boxes, but the reasoned choice of organisms was up to the pupils. Certainly this device led to some interesting reasoning from the groups, articulated both in speech and through pointing and object manipulation, as here in Catherine's research lesson 2:

S2: What do you think would eat the tree?
S3: Um, maybe the caterpillar might eat the tree?
S2: Not eat the whole tree.
S1: Well eat the plants.
S3: Yeah it'll eat the leaves.
S1: Wait lets just think about this. Lets see, that could go in there, and um then that, but that could be.
S3: Maybe the Mayfly could eat the leaves off the?
S2: I don't think (inaudible).
S1: No, no, no actually. Put this in there.
(One student removes the oak tree and replaces it with the algae)
S2: Algae.
S1: Then Mayfly, oh no back. Then maybe that could go on there yeah?
S3: Yeah.
S2: Oh what about the frog?
S3: But the frog could eat the Mayfly.
S1: Yeah eat that, and then the. What could be, what could the frog eat?
S3: No what could eat the frog? Maybe the owl could eat the frog?
S1: No, no.
S2: If a hedgehog was on there, that.
S1: Maybe.
S2: Unless if we could take that off, and put um, and put. Oh I know caterpillar.
S1: Yeah but that, the caterpillar wouldn't really eat that.
S2: Oh yeah no.
S1: That's in the water. Well so, we, why do you think that that could eat that?
S3: Because, and it lives in a habitat near the water.
S1: Ok.
S3: For the foods that it's got is that is the best one.
S1: I think that could eat that, the fly because um. Mayfly because um.
S2: Because frogs can eat fly, frogs can eat flies.
S1: Because they both have the same.
S3: Why don't we write our answers on the board?
S1: Well actually; no, no, no, no. What about if we put that there, that could.
(Students click and drag the suggested answers into the boxes on the IWB)
S1: That could be eaten like that.
S2: Oh yeah.
S1: Because they, they basically all have the same habitat and so do they. But the water spider can probably eat that, and then.
S3: Maybe we could swap it round.
S1: No that's.
S2: Why was the spider (inaudible)?
S1: So do you all agree with that?
S3: Do you agree with that yeah?

S2: Yeah.

Central to such exchanges, and to the reasoning associated with developing co-construction of task responses, are the twin IWB affordances of provisionality and stability, evident in the pupils' handling of screen objects. Stability suggests that, in devising the task, the teacher has determined that some objects (images, words, lines etc.) are available and in a set position unless the pupils choose, usually together, to move them. When they are moved, their new position is provisional whilst reasons for the position are discussed, and they are stable in their new position until the group decides to move them again. The IWB thus provides a systematic way of holding and accessing information during the period of collaboration. It is quite difficult, when working in a group at the IWB, to casually manipulate task objects on the IWB without group assent. Pupils may therefore be *required* to be more collaborative in their approach to the task than they might be otherwise (for example, in a similar task to the above lesson carried out with all the information on separate cards, the items can be constantly manipulated and moved by all members of the group). If the intention is active participation in science knowledge building through the creation of a shared, dynamic dialogic space (Wegerif, 2008) then the manipulation of these affordances in the design of IWB activities by the teachers may play a central role. Certainly, in all the case study classrooms the pupils would move objects, step back and consider their placement, reason and debate, move objects to show alternatives and, in general, demonstrate an active participation in their science learning.

3.2.3 Prompts for action

All three teachers included either specific instructions, problems, questions or suggestions - or a combination of all four - into their IWB task structures, firmly embedding their vicarious presence in the activities.

Her focus on data interpretation led Nina to start each set of pages with an extended scenario in which a data problem was outlined for the pupils. Thus, in the pilot lesson, the pupils are presented with different investigation scenarios and graphs for a dissolving task carried out by another class, but were told that the pupils in the class hadn't put their names on the jumbled elements of their work. The task was thus to ascertain which graph went with which investigation. Her research lessons started with similar scenarios. In Catherine's tasks the problem was often replaced with an on-screen question, as in her pilot lesson – 'How could you separate a mixture of buttons and sand, a mixture of water and sugar, aluminium cans and iron paper clips?' Scott tended to use a combination of direct instructions and a rather unique 'Mr. H. says' device, in which his picture appeared on screens with suggestions about what needs to be considered in a particular task. This device was used for direct instructions ('Mr. H. says discuss why you think each material is suitable, then as a group choose the best one'), to make suggestions about what the task might incorporate, or to give reminders that were linked to earlier spoken instructions ('Mr. H. says… remember to use the key words.'). All of these devices prompted the pupils in the various groups to read the prompt provided collectively and to act upon it. For example, with respect to Scott's 'key words' suggestion, the pupils ticked off key words used in their task response, articulating what they had done:

S1: 'Opaque' and 'blocks'.
S2: And oh.
S3: And we've done 'light', and we've done 'light'.
S1: Where is, oh yeah 'light's' there. Now we need to say something with a 'straight line'.

In all the research classrooms it was interesting to see that the teachers spent less time with the groups at the IWB than they did with other working groups. This may have been the result of their assurance that their vicarious presence in various forms, together with confidence in their pupils' assumed technical competence at the IWB and in the pupils' understanding of the components of successful collaborative work (Warwick & Kershner, 2008), would be a sufficient guide for the pupils' in tackling their science activities. However, direct and important interventions in the groups work at the IWB were also evident, though they were of a particular character. These are often associated with the resolving of simple technical issues, for example board orientation, but in our research classrooms direct interventions were also associated with reminders about how to proceed, picking up on issues related to science and to group talk. Sometimes direct intervention focused directly on what is happening at the IWB, using this as a springboard for questions or statements to the whole class.

4. Conclusions and discussion - linking affordances and mediated tasks at the IWB

We have illustrated some of the ways in which the vicarious presence of the teacher is apparent in the patterns of learning behaviour of pupils at the IWB and in the structure and content of the IWB activities. As a result of our research we would concur with Yoon et al. (2005) that the development and playing out of engaging science learning experiences are a function of the ways in which technology, the learning task and teacher support merge. Further, our research suggests that skilful manipulation by the teacher of the parameters for pupil interaction in groups - and of the ICT-based and other resources that they act in relation to - might be a key that is used to help create and unlock the potential of a dialogic space for pupil group work at the IWB.

As we have seen, particular affordances of the IWB are drawn upon by our case study teachers in mediating their constructed IWB environments for pupil learning in science. In order to draw out the particular intentions behind the use of these affordances, it is useful here to show their connections with the scaffolding classifications that are applied to teaching approaches in 'conventional' lessons. Teacher scaffolding of a task refers to the various ways in which the teacher seeks to create an engaging task environment that helps and supports the pupils in their cognitive, and metacognitive, activity. Wood et al. (1976) show how scaffolding strategies might be used across tasks to recruit learners to a task, to reduce their degrees of freedom when carrying out a task, to maintain the direction of a task and to mark critical features within it. Tharp & Gallimore (1988) show how the tactics of feeding back, and of direct instruction and questioning, can contribute to a scaffolded environment that promotes learning. In examining the ways in which the teacher's vicarious presence was evident in the structure and content of the created IWB environments, it is clear that various uses of IWB affordances actively scaffolded the pupils' engagement with, and success in, the tasks they undertook. Table 1 draws together some ideas from our case studies and suggests a possible way in which links might be made between broad notions of scaffolding and the particulars of teacher mediation of a task through the use of IWB affordances.

Table 1: Linking teacher use of IWB affordances and scaffolding strategies

In considering the links proposed in Table 1, it should be noted that we have focused on the use of the particular affordances evident in the constructed IWB environments of our three case study teachers, and the ways in which these might be seen to contribute to the

Perceived by teacher as an affordance	Allows pupils…	Example	Scaffolding strategies and tactics	Scaffolding intention
Object manipulation	Direct contact with the IWB - possibility of external representation of their thinking	Teacher provision of moveable objects and expectation that pupils will engage physically with them	Recruitment	Support of pupils' affective response (positive engagement in response to freedom to manipulate objects)
			Reduction of degrees of freedom (through the provision of limited moveable objects)	Support of cognitive activity
External memory	'Feedback and feed-forward' as part of on-going review of the task	Teacher use of the page sorter and page hyperlinks to guide the pupils	Direction maintenance	Support of metacognitive activity
			Feeding back	Support of cognitive activity
Provisionality, stability and permanence	Guidance on task parameters and possible approaches	Teacher locking and freeing specific board objects	Reduction of degrees of freedom (though note possibility of pupil intervention in teacher intentions)	Support of cognitive activity
Embedded IWB cues	Directions and guidance with respect to task expectations	Questions, instructions, Scenarios on IWB 'Mr. H. says…'	Direction maintenance	Support of cognitive activity
			Marking critical features	Support of cognitive activity
			Instructing and questioning	Support of cognitive & metacognitive activity

co-construction of knowledge by the pupil groups. The intimate relationship between cognitive activity, metacognitive activity and pupils' affective response to the tasks also becomes apparent. We saw numerous examples of the ways children engaged positively and directly with the screen objects, being keen to engage physically with the screen or enjoying their ability to control the pace of the task or the degree of repetition they engaged in. The links made in Table 1, between the use of specific IWB affordances and teacher scaffolding of the task, are thus important in articulating the ways in which the teacher's vicarious presence links not just with cognitive and meta-cognitive scaffolding intentions, but also with the intention to engage and excite the pupils in their own learning.

However, we need to look more widely at where the teacher's vicarious presence in IWB tasks, and teacher mediation more generally, 'fit' within the aspiration to develop a dialogic space at the IWB that can lead to pupils' collaborative science knowledge building. Figure 4 presents a schematic that expresses the relationship between the key components that might lead to the realisation of such a space and the consequent knowledge building that might derive from pupil interactions within it. It reflects the idea that the teacher provides a platform of direct and vicarious mediation – of the task and of the classroom rules and procedures – that enables the opening up of a dialogic space at the IWB. This space is not only where the pupils interact, but where they bring their own perceptions of the affordances for learning of exploratory talk and of the IWB environment as it has been constructed by the teacher. In other words, the vicarious presence of the teacher in the minds of the pupils and in the technology clearly has an impact on their learning behaviours, but it is not the only factor in play. Pupil intentions in their approach to learning tasks also influence their direction and potential for success, whilst the overall classroom participation structures (which we will consider in future publications) impact on the degree of freedom that pupils feel to act autonomously at the IWB.

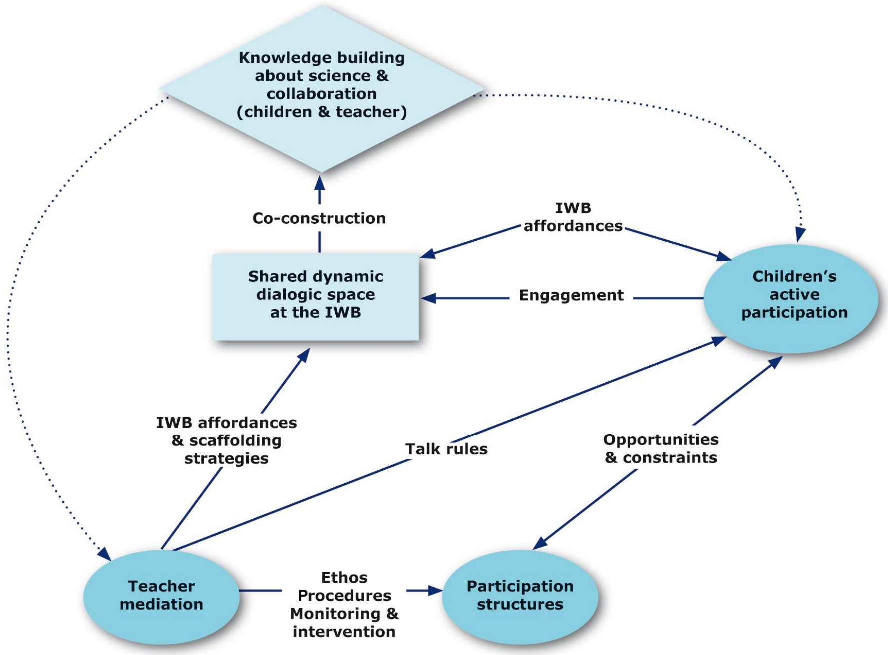

Figure 4: Teacher mediation of pupil group activity at the IWB

The bi-directional nature of the IWB affordance link on the Figure requires some further brief explanation. Here, we draw attention to the fact that the IWB affordances integrated by the teacher into the task structure can both provide a stimulus for children's active participation in tasks and facilitate the kinds of interactions that build a shared and dynamic dialogic space. But this cycle does not rely exclusively on the ways in which the teacher has mediated the activity at the IWB; the cycle of interaction can be developed where the pupils themselves perceive additional enabling features of the technology as affordances for learning (as where, in a class not considered above, the pupils began to use the facility to cut and paste objects as a means of expressing their understanding of the reflective and non-reflective objects).

In drawing together the elements of this study we have reflected on what may be necessary for successful interaction and science learning at the IWB. Yet it is important to acknowledge that in some of our 12 research classrooms the work carried out was not as successful, either in the intention of creating a dialogic space for learning or in the knowledge building that was evident in the working groups. There were several situations in which this was evident.

The first and most important of these was where the dialogic space was unsupported or interrupted. We have noted in previous work how pupil's active participation in knowledge building is built of several components – 'pupils' sensitive and informed support for each other, their joint awareness of task expectations, their acceptance of collective responsibility for completing an activity with some independence of the teacher, their perception of the importance of a division of labour that recognises individual strengths and the contribution of pupils' different skills to the collective thinking, talking and learning process' (Warwick & Kershner, 2008, p.279). What was clear in our research classrooms was just how important a sustained classroom focus on exploratory group talk is in achieving these components of productive interaction. Where there was little or no sustained emphasis in a classroom on how to talk productively in groups we saw inadequate, inappropriate or partial interaction by pupils working at the IWB, with a consequent effect on learning. But even where a strong focus on the building of a dialogic space was supported by an emphasis on talk rules, the development of the space could also be interrupted. Significant technical issues with the IWB, and the provision of inappropriate tasks - in terms of learning demand (Leach & Scott, 2004) or task complexity - caused pupils to disengage with tasks. In this last context it is worth noting that our data suggests that there may be task types that are particularly suited to creating positive learning experiences for pupil groups. These include open-ended tasks (e.g. sharing initial topic ideas); a series of cumulative tasks, the pace of which can be controlled by the children (e.g. reviewing previous learning); science investigations (e.g. data interpretation, considering experimental design and variables); and tasks integrating web-based materials (e.g. using web-based simulations and video resources).

In considering these issues in relation to the vicarious presence of the teacher in IWB tasks, several issues come to the fore. The first is that technology has no agency – it cannot, in itself, change classroom teaching and learning but rather requires mediation. The second is that the mediating role of the teacher is not confined to the direct interventions that might intersperse pupil interaction at the IWB – their vicarious presence is at least equally important. Related to this, it is clear that the way that the teacher creates a productive collaborative ethos, both in the class as a whole and for pupils working in groups, is central to the success of collaborative work at the IWB. Their vicarious presence in the minds of the pupils, at least at the point where the pupils are appropriating ways of interacting, is crucial. Finally, the ways in which the teacher employs their pedagogical knowledge in the pursuit of devising appropriate learning tasks, and how this links with their use of IWB affordances, is of central importance. The teacher's vicarious presence in the technology is a clear factor in the success, or otherwise, of groups working at the IWB.

Acknowledgements

We would like to acknowledge the support of the ESRC in funding this project and of the

Cambridgeshire ICT service in providing a range of help, advice and support. In particular we would like to thank our research teachers and their classes, and especially – given the focus of this paper – Nina, Catherine and Scott.

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Accepted for publication in Computers and Education, 2010. Please do not cite without permission.

Appendix: lesson details for the three cases

Class	Pupils	Lesson	Topic area	IWB activities
Scott – Millfield Community Primary School Year 5	Olivia Kayleigh Anne	Pilot	Light sources and reflectors	Examine learning objective Sort objects - reflective and non-reflective Select material for clothing Select colour for clothing Choose reflector or light source for clothing Light rays from source x2 Light sources and shadows Clothing design task
Scott	Olivia Kayleigh Anne	Research lesson 1	Life processes and living things	Examine learning objective MRS GREN task- identifying seven characteristics of life Identifying why an alien might think a car is alive (using characteristics of life) Identifying how a plant fulfils the seven characteristics of life Arranging pictures to form the life cycle of a bean Sorting living creatures- pond and not in a pond Making an accurate food chain Learning about different organisms on a website Science investigation- choosing a question to investigate explaining choice of question choosing areas of school to work in explaining choices
Scott	Olivia Kayleigh Anne	Research lesson 2	Life processes and living things	Examine learning objective 'Guess Who' Game Examining what types of questions they were asking in 'Guess who' game Generating sensible questions for separating different organisms Using a branching key to classify a jellyfish Using a branching key to work out the name of a fish Reading about organisms on a website Counting coloured diamonds in picture and generating a bar graph of results Science Investigation- choosing equipment for investigation describing how they will use equipment chosen describing how they could present results
Catherine Milton Road Primary School Year 5	Ben Georgia Isis	Pilot	Separating different substances	Selecting equipment for separating different mixtures Explaining choices for above Describing what can be used to separate different types of mixtures (large solids and fine solids, fine solids and water, large solids and water)
Catherine	Ben Georgia Isis	Research lesson 1	Animal identification – link to habitats	Examine learning objective As a class- generating 'Yes or No' questions to identify pupils Generating animal identification key
Catherine	Ben Georgia Isis	Research Lesson 2	Food chains (within Habitats topic)	Examine learning objective Arranging pictures to create a food chain Arranging pictures to create another food chain Explaining reasons for where they put items in the food chain Designing an animal that could feed on an owl – diagram with labels explaining features Describing what would happen to other animals on food chain if one animal was taken out and giving reasons for answers
Nina Lionel Walden Primary School Year 5	Archie Danielle Anna	Pilot	Data interpretation	Matching graphs to pupils' descriptions of water (using knowledge about dissolving sugar in water of different temperatures)
Nina	Archie Danielle Anna	Research lesson 1	Data interpretation	Matching graphs to pupils' menus (using knowledge of food pyramid) Describing reasons for matching each graph to each menu Choosing a menu (from the ones they'd used above) that provides 'the balance of good health' and describing reasons. Creating another menu that provides 'the balance of good health'
Nina	Archie Danielle Anna	Research lesson 2	Data interpretation	Matching graphs to circuit diagrams (using knowledge of different circuits on website) Researching Thomas Edison (extension task)