The role of digital artefacts on the interactive whiteboard in supporting classroom dialogue

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ABSTRACT

This paper explores how the interactive whiteboard (IWB) might be harnessed to support student learning through classroom dialogue. This powerful and increasingly prevalent technology opens up opportunities for learners to generate, modify and evaluate new ideas, through multimodal interaction along with talk. Its use can thereby support rich new forms of dialogue that highlight differences between perspectives and make ideas and reasoning processes more explicit. The emerging account builds upon Bahktin's conception of dialogue and Wegerif's notion of technology "opening up a dialogic space for reflection", but foregrounds the role of mediating artefacts. Classroom dialogue in the context of IWB use is construed as being facilitated by teachers and learners constructing digitally represented knowledge artefacts together. These visible, dynamic and constantly evolving resources constitute interim records of activity and act as supportive devices for learners' emerging thinking, rather than finished products of dialogue.

This primarily theoretical account is illustrated with examples from case studies of UK classroom practice. Analysing lessons in sequence has illuminated how teachers can exploit the IWB through cumulative interaction with a succession of linked digital resources and through archiving and revisiting earlier artefacts. The tool thereby helps to support the progression of dialogue over time, across settings and even across learner groups. In sum, the article reframes the notion of dialogue for this new context in which students are actively creating and directly manipulating digital artefacts, and offers some practical examples.

1. INTRODUCTION

The extent to which technologies can facilitate dialogue is the extent to which they succeed as educational tools. (Johnson, 2011, p.E246)

This paper develops a theoretical framework for understanding notions of classroom 'dialogue' and the mediating role of artefacts in the context of interaction with the interactive whiteboard (IWB)[i], a relatively new cultural tool that is typically used for whole class teaching. The technology is now found in over 70% of UK classrooms (Futuresource Consulting, 2010, p.319); its prevalence is rapidly increasing in a number of other countries too, notably Denmark and Netherlands (40-42% classrooms in 2009), USA, Australia, Ireland and Mexico (almost 30% classrooms). The account is a theoretical one drawing on and synthesising published research that has recently been carried out mainly in the UK but in some other countries too. Although primarily a position paper, it also builds heavily on analyses of classroom observations of teachers exploiting IWBs to support subject teaching and learning, conducted by the author in collaboration with a number of colleagues.

The article charts new territory by exploring the potential of using the tool in the classroom to support an established dialogic pedagogy, and by foregrounding the role of mediating artefacts in this process. Thus it goes beyond traditional conceptions of dialogue as 'talk.' The account shows how IWB use can additionally open up a space for rich new, multimodal forms of dialogue. The potential is for new dialogues to revolve and evolve around digital artefacts jointly created by teachers and learners on the IWB. These provisional knowledge objects represent earlier as well as current actions and thinking; importantly, this helps both to highlight differences between perspectives and to maintain continuity of dialogues over time. The account illustrates the various ways in which the cumulative and recursive interactions central to extended dialogue are facilitated by IWB technology use. It is proposed that by rendering both learning histories and trajectories more visible, digital artefacts can facilitate the cumulative progression of dialogue. It concludes by offering a perspective on the outcomes of drawing learners into a dialogic space. It is argued that these include skills for dialogue, reasoning and enquiry as well as diverse, fluid forms of disciplinary knowledge that are both personal and shared, internally and externally represented.

The supporting evidence is drawn from three research projects[ii] involving 10 in-depth case studies of 8 teachers using IWBs in a variety of subject areas carried out in (mainly secondary) schools in the East Anglia region of the UK between 2002–2009. The methods and outcomes of this research are detailed in a number of other publications, but extracts of the data appear here by way of illustration (drawing particularly on observations of one history teacher participating in two projects). Suffice it to say that in these studies video recordings of 2-6 lessons / teacher, teacher diaries, observation and meeting notes were iteratively reviewed in conjunction with post-lesson interview data and screen shots of IWB artefacts in the making. Note that the examples extracted from the second project, *T-MEDIA*, are elaborated using digital video and commentary in the resulting online multimedia professional development resources.[iii]

The most recent of the projects was undertaken in conjunction with Neil Mercer and Paul Warwick and investigated *IWBs and Dialogic Teaching*. We entered three 'dialogic' classrooms (in a primary school, a middle school and a secondary school) and investigated the roles of the teacher and the

available IWB technology in mediating student learning through participating in classroom dialogue. Uniquely the methodology centred around a process of joint theory building with the participating practitioners (Hennessy, Warwick, & Mercer, 2010, in press) in which the notion of dialogue was interrogated, refined and recontextualised for IWB use. The theoretical account in this paper builds on some outcomes of that process as well as on the research literature and the author's subsequent reflection on the issues emerging. In addition to conducting observations, we collaboratively analysed lesson videos and discussed 'critical episodes' using selective transcripts of dialogue to understand, reflect on and develop the roles of teacher and technology. We thereby explored how established dialogic pedagogy may drive teachers to exploit this powerful new tool to support collective knowledge building over time. It thus complements the parallel line of work by Mercer, Littleton, Warwick, Twiner, Gillen, Kleine Staarman & Kershner on 'dialogic space' afforded by collaborative use of the IWB in primary schools; their emphasis was more on children's reasoned discussion and the roles of task design, as elaborated below. A couple of the exemplars included from this project are again supported by links to video clips online.

The account begins by introducing the underlying perspective on dialogue in the next section – as being cumulative, responsive and based on exploring differences between perspectives. Section 3 then proposes some affordances of IWB technology for supporting exploration of difference through *multimodal* forms of classroom dialogue, primarily through creating and manipulating digital artefacts in conjunction with talk. Section 4 illustrates how such IWB-supported dialogue and enquiry are cumulative and hence learning is progressive over time, aided particularly by revisiting earlier artefacts. Section 5 discusses the potential outcomes of dialogues. Finally, overall conclusions are drawn about how a dialogic space created by IWB use can be productive for learning.

2. LEARNING THROUGH DIALOGUE

2.1 Conceptions of dialogue

The term dialogue is defined as "discussion directed towards exploration of a subject or resolution of a problem" (Oxford English Dictionary). The notion of dialogue developed here builds on the writings of Bakhtin who similarly defines dialogue as shared enquiry (as opposed to conversation). His account and subsequent related work by Wegerif (2007) describe 'dialogic' as the gap between two or more perspectives held together in the tension of a dialogue, and meaning as arising within that gap. Implications for dialogic classroom interaction as an evolving *pedagogical approach* are additionally characterised by Mortimer and Scott (2003) and Mercer (1995; Mercer & Littleton, 2007), who recount how teachers and learners actively comment and build on each other's ideas, posing questions and constructing new knowledge. Implicitly underpinning a dialogic pedagogy is an intersubjective epistemology that emphasises social agency and locates learning at the community level of interaction (Suthers, 2006). Classroom dialogue thus encompasses a form of shared cognition (based on a common focus of attention and some shared presuppositions) that facilitates exchange of ideas and negotiation of new meanings *in accordance with others' perspectives* (Rogoff, 1990). This is akin to the cumulative nature of dialogue, termed 'addressivity' and 'responsivity' by Bakhtin, referring to how an utterance is shaped in anticipation of a certain kind of response from the intended listener as well as responsive to previous utterances and meaning making (Bakhtin, 1986, p.91). Participants in dialogue construct meaning through chained sequences of questioning and responding (ibid.) and chained lines of thinking and enquiry (Alexander 2008).

Traditional conceptions of dialogue are centred around the notion of language (Cole, 1994; Volosinov, 1973), recently described as "the most ubiquitous, creative and flexible of the meaning-making tools available, and it is the one most intimately connected to … the pursuit of reasoned argument" (Mercer & Littleton, 2007, p.2). While 'language' may be more broadly construed as encompassing other communicative representations, classroom talk in particular is currently privileged in the school context as "central to the meaning making process and thus central to learning" (Mortimer & Scott, 2003, p.3). One relevant type of quality talk identified is 'exploratory talk': a means of constructing shared knowledge whereby reasoning is visible in the talk (Mercer, 1995). Participants justify their views, are willing to change their minds and reflectively criticise their own ideas. Preconditions for this kind of talk include cultivating a supportive classroom ethos for exploration and sharing of ideas. Drawing learners into extended and thought-provoking question-and-answer exchanges is associated with improved learning outcomes (Rojas-Drummond & Mercer, 2004).

Recent incarnations of national examinations and policy strategies in the UK have moved increasingly towards an emphasis on classroom discussion of controversial topics and development of dialogue skills in subjects such as history, geography, science and citizenship.[iv] Yet a conflicting policy (and school inspection) emphasis on rapid lesson pace (disregarding the desired *pace of learning)* and soliciting correct answers, coupled with many teachers' and policymakers' lack of understanding of dialogic pedagogy, mean that a dialogic approach and 'exploratory talk' are not commonly observed (Galton, 2007; Mercer & Littleton, 2007). A parallel can be drawn here with the difficulties pertaining to conducting genuine enquiry in the classroom, namely where learners generate their own questions, explanations and tentative theories. Hakkarainen (2003, p.1086) argues that an established culture of fact seeking means "a substantial epistemological shift in pedagogy and the wider culture of schooling is needed" to infuse an enquiry stance into all learning activities. In many classroom communities a similarly radical shift would be needed to create a supportive social infrastructure (Bielaczyc, 2001) for exploring ideas through dialogue.

2.2 Exploring difference within a dialogic space for reflection

At this point we edge away from the prevalent sociocultural perspective and consider that use of spoken language as a shared tool for reasoning *per se* (Mercer, Dawes, Wegerif, & Sams, 2004) may not in any case be the key mechanism for success; improved problem-solving performance can result from a particular kind of dialogic silence, or long pause. Wegerif (2007, 2008) postulates that the ground rules and shared enquiry characteristics of exploratory talk (e.g. asking open questions, listening with respect, self-critique) serve to open and maintain a dialogic 'space of reflection.' This allows creative solutions to problems to spontaneously emerge – although exploring and rejecting possible solutions may help to prepare the ground for such breakthroughs. Wegerif argues that the dialogic space is more fundamental than words. He construes the dimension of creative reasoning in dialogue as a "dance of perspectives" in which each new perspective on a problem is labeled (Wegerif, et al., 2010, p.615). From Bakhtin's (1981) dialogic perspective, meaning arises in the context of a difference between voices opening up a space for dialogue, so that (in contrast with established perspectives[v]) differences are in no sense contradictions needing to be overcome. Wegerif et al. (2010) contrast this metaphor of 'thinking as dialogue across difference' – and hence

teaching and learning as drawing students into spaces of dialogue across difference – against other perspectives including thinking as cultural tool use. Wegerif concludes that thinking is a response to new challenges within a dialogic relationship, so that out of the tension between viewpoints comes not only criticism and judgment but also insight and understanding (Wegerif, 2010b, Chapter 1).

A series of studies of 'alternative conceptions' in science by Howe and colleagues (Howe, 2010; Howe, McWilliam, & Cross, 2005; Howe, et al., 2007) provides substantial empirical evidence for "the power of difference in the pursuit of shared goals" (Howe, 2010, p.41). The research shows that within-group resolution of differences – requiring principled evaluation of competing ideas and production of a superior account – is not only rare but has no immediate impact on learning, as measured by post-test performance. Instead disagreement may create contexts where propositions and explanations are more likely. It is these that are associated with increased understanding when teachers are non-directive. Exchange, recording and evaluation of differing views during high quality group dialogue can, however, unsettle children and motivate them to reflect privately on the content and on subsequent experiences long after the group interaction, thus making significant conceptual progress. The notions of unresolved contradiction – rendering conflicting conceptions more salient – and 'delayed resolution' (Howe, et al., 2005) seem consistent with that of a dialogic 'space of reflection' upon multiple perspectives (Wegerif, 2010a). Ultimately exploring difference with others culminates in independent thought (Ryan, 2009).

We recently explored with collaborating teachers the question of whether participants in dialogue need to try to reach a consensus view, as is sometimes suggested explicitly (e.g. Mercer & Littleton, 2007, p.72-73; Toulmin, 1958) or implicitly (e.g. Gee & Green, 1998). The phrases 'common understanding' and 'common knowledge' (Edwards & Mercer, 1987) are sometimes interpreted in terms of convergence, although Floriani (1993, p.263) asserts that "having common knowledge does not mean or insure one way of interpreting history [in its widest sense]." Feito (2007) in his article on "allowing not-knowing" has likewise observed very little consensus seeking or summarising in a dialogic classroom where authority is decentralised. Wegerif (2007, p.282) suggests that dialogue is "characterised by uncertainty, multiplicity and open-endedness" and observes that children successful at problem solving are more able to remain with the silent pauses in such dialogue. Thus divergent thinking and challenge increase the potential for dialogue – as described by one student who told me, "I think if you are [working] in a pair you've got the problem that if they don't have a different view, you don't really have anything to do."

The key authors in this field concur that disagreement offers an important stimulus. However Mercer and Littleton (2007) and Howe et al. (1992) also helpfully assert that working towards a carefully reasoned consensus viewpoint – in terms of weighing up the relative strengths of one's own and others' opinions to achieve a group view rather than acquiescence to another or majority view (which may be conceptually inferior to one's own) – keeps participants fruitfully engaged with others' ideas (Wells, 1999). Our team ultimately agreed and concluded that an appreciation of a number of different valid views, sometimes culminating in a synthesis of those views, is itself a key outcome of dialogic interaction (Hennessy, et al., 2010, in press). In sum, *reaching consensus* is unnecessary, and insisting on convergence is in fact monologic; Howe et al. (2007) report that premature closure undermines delayed resolution and obstructs learning. However *striving for consensus* may be fruitful because making difference and uncertainty explicit, and reasoning about areas of

disagreement, provide an incentive for communication and change. Open-mindedness is central here, or being "open to otherness" (Wegerif, 2010a, p.319) so that entering a dialogic space means a shift from narrow concerns, fixed identity and authoritative knowledge.

The discussion now articulates the role of IWB technology here. It begins by documenting some affordances supportive of exploring difference through collaborative enquiry, especially using modes of communication other than talk.

3. BEYOND 'TALK': THE AFFORDANCES OF INTERACTIVE WHITEBOARD TECHNOLOGY FOR MULTIMODAL CLASSROOM DIALOGUE

The choice of the IWB as a technology context to research relates to its unique status as a *generic* classroom tool as well as to its physical dominance of the teaching space. Through being linked to a computer with internet acess, it is an unrestricted portal for interaction with an infinitely wide range of secondary digital resources. This offers teachers tremendous ease and flexibility in sourcing materials to stimulate dialogue. In addition IWB use can support community knowledge building through text and object construction within its proprietary software environments, aided by its specialised tools for direct manipulation of digital objects.

In this section I argue that using the IWB can potentially support collaborative learning by making differences between perspectives more explicit while understanding is developing. It opens up new opportunities for learners and teachers publicly to express, explain, justify, evaluate and reformulate ideas – both orally and using other rich symbolic representations. This account is based on the central premise that *"we think with and through artefacts"* (Säljö, 1995, p 91) and these artefacts constitute mediational means (Wertsch, 1998) with particular affordances (Gibson, 1979) and constraints. In other words, they can facilitate or inhibit certain patterns of action. The increasingly recognised role of artefacts in cognitively mediating between individual and world is of particular relevance to the IWB context, where digital artefacts are co-constructed by learners and teachers. However the goal of such interaction is not to learn to use the IWB as a cultural tool. It is to use it to draw learners into new forms and spaces of productive dialogue between different perspectives, as elaborated below.

3.1 The trialogical approach to learning
Digital artefacts on the IWB are viewed as collaboratively created and evaluated for immediate or subsequent communal use, in reciprocal meaning making. This resonates with the *(artefact or) knowledge creation metaphor of learning* outlined by Paavola and Hakkarainen (2005) and Hakkarainen and Paavola (2007). The interaction between individual expertise and communal knowledge is said to be 'materialised' as new, shared objects of activity are developed for subsequent use. Hence individual initiative serves the communal effort to create something new. This 'trialogical' approach to learning contrasts with the monological *knowledge acquisition* and dialogical *participation* metaphors of learning (Sfard, 2006). Interaction takes place through – and knowledge becomes embodied in – mediating artefacts and practices (rather than being acquired by individuals or constructed in social interactions). Trialogical objects include both material artefacts such as practices or reports and conceptual artefacts such as research problems, theories, questions and designs. These may be externally represented using text, graphics, photographs, sketches etc.

The key characteristics of the trialogical approach are that it:
  (1) concentrates on processes which aim at developing shared objects;

  (2) takes place across long timescales;

  (3) involves interaction between individual and collective processes;

  (4) relies on cross-fertilisation of knowledge practices;

  (5) relies on collaborative technologies designed to elicit object-oriented activities;

  (6) develops through transformations and reflections across forms of knowledge.

These features could also be argued to characterise dialogue in the context of IWB use. The focusing on developing shared artefacts and continuity over the longer term, under-represented in some accounts of dialogue, constitute a particularly helpful starting point. Whereas artefacts are viewed by the trialogical approach as products, however, the particular strength of the IWB technology is its support for continuous development of ideas, as elaborated below.

3.2 Digital artefacts

The IWB (incorporating both hardware and software) is often construed as a mediating artefact: a primary artefact that is directly used (Wartofsky, 1979). Mediation is made by the teacher and students – who need to understand the mode of functioning of the tool in relation to the goals of the activity it mediates (Cole, 1994). In this context goals are both dialogic and substantive. Digital artefacts are secondary artefacts rather than mental entities. They are actual physical or perceptual "reflexive embodiments of forms of action or praxis, in the sense that they are symbolic externalisations or objectifications of such modes of action – 'reflections' of them" (Wartofsky, 1979, p.201-2). Wartofsky argues that the artefact is the vehicle of information across generations. It underpins cultural evolution – through being redesigned to achieve new goals and activities (Pea, 1993).

From this perspective, talk as a tool for interrogating difference no longer hogs the limelight. Wells (1999, ch.3) adopts a broader view of "utterance" and of "knowledge artefacts" than the usual association with talk and written texts. He refers to "any semiotically mediated activity" and to understanding development through action too (whilst acknowledging that talk has some unique qualities and plays a significant role in collaborative work). An object orientation is central to his account and is considered the source of the powerful and generative nature of enquiry. Nevertheless examples given in fact centre around talk and writing as devices for thinking, i.e. as supportive of the *process* of coming to understand a subject area rather than merely to communicate. These linguistic devices may indeed together constitute the most powerful semiotic system available to us. However, understanding of the role of other artefacts as mediators of social cognition (facilitating shared memory and communication of ideas, eg Säljö, 2009) is also important, albeit presently hazy. In this account I construe a digital artefact produced on the IWB as both a "knowledge artefact" and "improvable object" (in Wells' terminology). It is not a container (Pea, 1993) but a symbolic, externalised representation of the sociocognitive activity that is taking and has taken place.

Interaction with digital artefacts can make new conceptual perspectives available to learners through laying them open to collective scrutiny.

3.3 Multimodal representation

Recent work on multimodality (eg. Jewitt, 2006; Kress, Jewitt, Ogborn, & Tsatsarelis, 2001) assists us further in understanding the complexity of classroom interaction through focusing attention on its multiple communicative modes. Modes are organised sets of semiotic resources for representation and communication, including image, gesture, gaze, interaction with objects, writing and speech. Situated communication always involves multiple modalities of meaning making (Lemke, 1999). The IWB currently acts as a focal point in many classrooms for multimodal interaction with digital media resources. These include texts, drawings, diagrams, still photographs, multimedia presentations, animations, simulations and models of dynamic processes, interactive diagrams, maps, concept maps, databases, graphs, tables, hyperlinked web pages, audio and video files, mathematical representations, etc. The potential of graphical and dynamic representations in rendering complex concepts and processes easier to share, discuss, visualise and understand is recognised by students and teachers alike. Digital resources and co-constructed artefacts can take any of these forms or employ combinations of them. They can in fact communicate meaning less abstractly than oral texts (Wells, 1999, ch.4) because interaction with them is usually mediated through both teachers' and students' interpretative talk, gaze and gesture at certain points during the course of activity. This offers opportunities to check understanding and supply clarification. Recent Mexican work identifies gesture as "the main orchestration strategy to organise talk, electronic resources displayed on the IWB, and participation of students in a coherent whole" (Fernández-Cárdenas & Silveyra-De La Garza, 2010, p.184).

In our case studies, we attended to teachers' and learners' exploitation of the multiple modes of representation (aural, visual, textual, graphical etc.) enabled by the IWB and its software rather than carrying out a multimodal analysis of their interactions with the board (attending to gesture, gaze etc.). We also looked holistically at how construction of digital artefacts is supported by related activity and resources employed *away from the board*. There is not space to describe this analysis in detail here; it is the subject of another paper by Hennessy (in preparation),which introduces the notion of a *'dialogic classroom space'* and elaborates the teacher's complex strategies for orchestrating this wider dialogic activity. Moreover we have observed how teachers combine complementary modes (a 'multimodal ensemble': Jewitt, 2008) and use them to contextualise and enrich each other in making sense of the ongoing activity. For instance one English teacher observed played an audio recording of a poet (Simon Armitage) reading his own gritty text in his regional accent; the text and a photograph of the poet were simultaneously displayed. The experience made the poem come alive for learners, allowing them insight into the author's perspective; since poetry's meaning resides with the listener or reader, however, that meaning became one of many as different learners in the class constructed their own (Hennessy & Bullock, in preparation). This kind of IWB use opens up and shapes a dialogic space (construed as both physical and cognitive) through engaging learners and offering them an opportunity for exploring difference in the course of forming their own views. Such exploration includes considering particularly pertinent perspectives juxtaposed with those of peers and teacher – fostering a creative tension (Wegerif, 2007). In some contexts, such as teaching science disciplinary knowledge, it is of course then desirable to foreground and clarify an authoritative view (Scott, Ametller, Mortimer, & Emberton, 2010).

Exploring ideas dialogically with the aid of digital resources can help to build up and make accessible the 'scientific story' (Ogborn, Kress, Martins, & McGillicuddy, 1996).

The dynamic interaction between learners' own talk and a given (projected) text (described by Wells, 1999, ch.4) is another example of the strength of modes in combination. Here I build on a sociolinguistic tradition of work on *intertextuality* and in particular Floriani's (1993) illustrations of how written texts are shaped by and related to oral texts or "talked into being" (p.242). This takes place in different ways according to what each mode affords. Thus, examining only one kind of text provides only a partial understanding of what participants construct. That work is extended here through exploring how digital artefacts are likewise collectively constructed in action (I prefer "artefacts" to the conventional "texts" as the term more saliently encompasses graphical and other nonlinguistic modes of representation). As illustrated in subsequent sections via examples from practice, these artefacts are manipulated or annotated, chosen as significant, reconstructed from different points in time, revisited, interpreted or critically analysed, negotiated and modified. This happens in conjunction with spoken dialogue that offers students opportunities to make links with previous tasks and to reconstruct meaning (Green, Yeager, & Castanheira, 2008; Scott, et al., 2010). In this way, talk is used as a tool along with other resources for social action by both learners and teacher to create a shared framework of understanding as a basis for joint knowledge building. In particular part of the teacher's role is to question, recap, elaborate and reformulate students' contributions (Mercer, 2004). S/he is thereby actively "interweaving different modalities" to "create cohesion and continuity from what might otherwise be seen by students as no more than a series of disparate events" (Gillen, Littleton, Twiner, Staarman, & Mercer, 2008, p.357-8).

3.4 Other affordances supportive of dialogue

The visibility of the large IWB screen and its interactive tools clearly offer an advantage over other systems designed to support collaborative learning. It helps to maintain a simultaneous focus of attention for large learner groups and allows them to jointly construct digital artefacts through a process of negotiation that imbues them with meaning. Stenning et al. (1999) argue that educational dialogue is particularly amenable to capture and reuse because it makes explicit inferences that would normally remain unspoken. It is here that activity based around the IWB plays an important role. It goes beyond purely oral forms of dialogue to create new kinds that make the cognitive goals and reasoning processes of the IWB users more tangible. Features perceived as supporting this include dynamic representation of processes, simultaneous display and comparison of different processes or objects, and meaningful feedback contingent on user input (Kennewell & Beauchamp, 2007). Use of unique tools such as those for highlighting and (graphical or textual) annotation of projected objects can be particularly effective in drawing attention to salient aspects of a representation, as in the following example in which audio and textual resources were again combined.

Figure 1 approximately here

A primary school teacher, Diane, played an audio file of herself reading out a personal safety scenario for children (aged 10) to discuss. This allowed her to devote full attention to observing individual children's responses. Rowena, a student, was then asked to take "suggestions about what people think is really important" from the class, and she highlighted the text on the IWB accordingly (Figure 1). Finally, she annotated around the text to represent her peers' understandings of the

characters' feelings. In this second stage, students were evidently stimulated to go beyond the printed text, generating and explaining their own ideas and illustrating empathy (e.g. "beaten", "confused"). Note that Littleton et al. (2010) offer a similar example of primary children interpreting a character's feelings, in that case enterprisingly annotating frozen frames of a DVD extract played on the IWB. They describe how the teacher "reworks and recasts, and gives authority to pupils' contributions, reframing and legitimating them within the lesson context – thus the object is improvable through the interaction and discourse around it" (p.135). In our example the teacher successfully managed the dialogue within a whole class containing a large proportion of children with behavioural difficulties and other special needs. She maximised participation through selecting volunteers carefully, continually monitoring engagement, and asking a student to record at the IWB. She mediated the discussion within the class and during the follow-up small group activity, engaging with the detail of their contributions. She deliberately refrained from revoicing their contributions, though, to encourage children to develop confidence and skill in expressing their own ideas. Ultimately she was very impressed with the words the students generated (Fig. 1), commenting that it was rewarding to see individuals who were shy, quiet and easily confused, producing really relevant input.

The digital artefact being iteratively constructed in the above example exploited the affordance of direct manipulation to actively develop, share and reformulate joint meanings. This affordance supports easy experimentation and reasoning activities such as visualising or modelling a problem, scenario, event or process; planning; explicating ideas and arguments; co-constructing or deconstructing texts and other artefacts to create new, richer ones. For instance, Jewitt (2009, in press) describes how an original poetry text can actually disappear – "becoming visual and fragmented (although these new fragments are perhaps being woven into a richer cloth of experience)." Its imagery is thereby reshaped as the relationship of word and visual image. Figure 2 depicts an example of transforming a poetry text . The sequence of slides illustrates how the originally projected text has indeed disappeared in the course of a developing dialogue that is nonlinear and interwoven with the evolving artefact(s). The dialogue thus launches itself in new directions from the preceding reifications of previous acts. Here it explores a character's feelings, the significance of an evocative image (second slide) for the poem's persona, and the ways in which the image and poem, plus other poems studied, reflect today's society. Its provisional reification within the artefacts, capturing learners' interpretations, is evidently facilitated through exploiting the affordances of direct manipulation, highlighting and annotation of images and texts by hand in real time during discussion.

Such IWB activity offers an immediate responsiveness and additionally, a personal character, whereas type is perceived as more authoritative and pre-meditated (ibid). It also highlights the "added value" of the IWB over a computer and data projector alone. Some parts of this activity and the others described in the article could potentially be carried out without the technical interactivity, for example when displaying a sequence of pictures or a single picture along with a voiceover. However exploiting the added functionality and the responsiveness can significantly extend and enrich the experience.

Figure 2 approximately here

This section has outlined some affordances of IWB technology for supporting dialogue through exploring and representing differences in perspectives. These underpinned the process of co-constructing and manipulating digital artefacts, in conjunction with talk. They included access to a wide range of digital resources, visibility, multimodality, dynamic representation of processes, contingent feedback, focusing attention through highlighting and annotating, juxtaposition and direct manipulation of objects and processes. The particular affordances of the IWB depend of course on the context in which it is used. The interface to any technology in no sense determines the quality of interactions or the understanding that is developed (Mercer, 1993), it merely facilitates. Research confirms that pedagogical interactivity is more important than technical interactivity in stimulating the reflection and intentionality of higher-order learning (Kennewell & Beauchamp, 2007), thus the teacher's and students' actions are pivotal, as discussed below.

4. USING DIGITAL ARTEFACTS TO SUSTAIN AND PROGRESS DIALOGUE CUMULATIVELY

Let us turn now to consider in more detail how teachers and learners perceive and exploit the aforementioned – and some further – affordances of the IWB in practice. The focus here is on two, interrelated features of dialogue facilitated by IWB technology: cumulative and recursive interactions that serve to progress learning over time – within and across lessons. Such interactions exploit the complementary affordances of *provisionality* and *stability* of IWB resources and artefacts. These affordances offer the freedom to save, re-use or continue building on an evolving artefact, or to treat it as purely transient and modifiable, according to purpose.

In this section it is proposed that by rendering both learning histories and trajectories more visible, IWB digital artefacts can facilitate the cumulative nature of dialogue. Note that in our collaborative work with teachers during the *IWBs and Dialogic Teaching* project, we adopted and elaborated Alexander's (2008) definition of 'cumulative' as orientation to and building upon others' contributions. We noted that the term 'cumulative talk' is used quite differently by Mercer (2000) to mean passive, uncritical accumulation of utterances in which contextual references are left implicit and individual differences in perspective are minimised. Alexander's account of teachers offering learners individually tailored responses during dialogue is more akin to Mercer's 'exploratory talk;' there partners build critically and constructively on others' utterances, actively offering suggestions and justified arguments for joint consideration.

While cumulative interaction is a critically important characteristic of the dialogic process, it is the hardest to achieve (Alexander, 2008). Meaning making through interaction in a whole-class setting is a complex process requiring learners (and teachers) to draw on their own individual resources, previous experience or knowledge of the target subject matter, and the relevant classroom discourse from earlier interchanges or lessons. Additionally, they have to shape their contributions in response, as Wells (1999, p.107-8) elaborates:

> One has to interpret the preceding contribution in terms of the information it introduces as well as of the speaker's stance to that information, compare it with one's own current understanding of the issue under discussion, and then formulate a contribution that will, in some relevant way, add to the common understanding achieved in the discourse so far, by extending, questioning or qualifying what has already been said.

If, however, the discourse context involves IWB digital artefacts rather than talk, then the process of recording in a relatively stable way enables the learner to visualise previous contributors' ideas and connections between them rather than having to hold them in short-term memory. (Gillen, et al., 2008, p.356 describe how "the IWB forms a cumulative backdrop as an updating source of reference and attention for the development of ideas"). Thus learners can interact with and respond to a greater range of ideas. Objects remain stable for as long as desired, yet at the same time they are provisional and can be debated or moved in the course of considering alternatives (Warwick, Mercer, Kershner, & Kleine Staarman, 2010). By contrast a nondigital board affords one 'screen' that can be displayed throughout a lesson, or erased and replaced with further single screens, but is in the longer term temporary (Jewitt, 2009, in press). As elaborated further in the following subsections, dialogue in this context might therefore be construed as *cumulative* in several ways – all mediated by the teacher:

1.   Contributions are immediately *responsive* to and constructed upon those of others;
2.   Contributions accumulate over time (across lessons) so that learners further develop their own prior knowledge and ideas through *'progressive discourse'*;
3.   *Revisiting and sometimes repurposing* records produced earlier is a form of recursion that again supports cumulative dialogue and it may be teacher- or student-led;
4.   *Interaction with artefacts created by other learners or experts* renders learning cumulative over space and time in a particular way not easily afforded by other technologies.

4.1 Responsivity

Let us begin by examining the notion of cumulative in terms of responsivity and accommodation to others' ideas. A single rich resource can be progressively manipulated and interacted with in different ways for different purposes, often within the relatively short time period of a lesson. The artefact is essentially transformed to become multiple artefacts or incarnations of the original. Examples of responsivity being built into the activity itself include (a) the progressive building up of a food chain (Figure 3) with each student using drag-and-drop to add a link in turn and communicating their reasoning (Hennessy, Deaney, Ruthven, & Winterbottom, 2007), and (b) the graphical annotation by successive students of a digital photograph of a historical portrait (see Figure 4 and Video Clip 1). Here learners subsequently interpreted their peers' thinking by drawing links to labels that others had written without comment around a projected digital photograph of a historical portrait (of the young Queen Elizabeth I). This activity developed a collective, enhanced understanding of the "Golden Age" of Elizabeth (Deaney, Chapman, & Hennessy, 2010). It also maximised the number of students that could interact directly with the portrait. The teacher built upon the students' interpretations in the plenary by subtly helping them to understand Elizabeth's motives and subsequent events. He created continuity by comparing the portrait with a previously displayed one of the older Elizabeth. He questioned the 'reality' portrayed by any historical artefact, concluding both that pictures only tell a partial story and that his own ideas had been changed by the activity. In this democratic classroom, the teacher was also a learner.

Figures 3 & 4 approximately here

These examples illustrate how use of continually accessible and visually displayed artefacts may support collaborative knowledge building in new ways. Similarly, the text and graphical notes produced using "progressive enquiry" systems such as Computer-Supported Intentional Learning

Environment (CSILE: Scardamalia & Bereiter, 1994), now called Knowledge Forum (a networked learning environment offering a shared virtual space for articulating conceptions and building, searching, linking and appropriating knowledge: (Hakkarainen, 2003)), remain readily accessible. Wells (1999) suggests that this renders them much more likely to be responded to in a dialogic, cumulative knowledge building manner than more transitory oral discourse. He proposes that diagrams, drawings, working models, maps, proofs, algebraic equations, musical performances etc. can play a similarly important role in knowledge building and can likewise give rise to "lively conversation" that helps to progress a discourse. Such "improvable objects" are particularly effective if they represent the creator's current understanding, for which an explanation has to be given to justify its acceptance (Wells, 2009, p.290), as happened in the two examples above. The process of explaining to other enquirers fosters deep conceptual understanding as weaknesses, inconsistencies or limitations in the "knowledge object" tend to become more salient (Hatano & Inagaki, 1992); recognising inadequacies is likely to motivate its improvement through joint activity. Creating concrete representations and receiving feedback allows learners to oscillate productively between their own tentative explanations and critique of their externalised representations from another's perspective according to Hay's (2008) account of dialogical concept mapping. This is expected to apply to use of the IWB too (which incidentally constitutes a potentially powerful forum for concept mapping).

Finally, the well-recognised affordance of provisionality underpins the notion of improvability in the context of IWB use (likewise in CSILE and similar environments). Digital artefacts are dynamically constructed, easily and infinitely manipulable by teachers and learners – in readily reversible ways that support the temporary exploration of ideas (Twiner, Coffin, Littleton, & Whitelock, 2010). Like utterances (Bakhtin, 1986), they are never final or fixed but exist transiently within the dialogic space. The developing knowledge structures associated with artefacts created using an IWB are "open to modification, expansion, and revision by members as they interact across time and events" as with other cultural models (Gee & Green, 1998, p.124). Gee and Green drew on Spradley's (1980, p.9) notion of a cognitive map that we constantly redraw to serve as a guide for interpreting our experience, responding to unanticipated events. In sum, use of the IWB perhaps helpfully allows evolving cognitive representations to be externalised, further shaped and utilised for interpreting and organising new ideas.

4.2 Dialogue and co-enquiry progressing between lessons

Constructing and interacting with evolving digital artefacts at the IWB can facilitate development of a coherent line of co-enquiry that is sustained over the longer term, extending the dialogic space beyond the scope of a single lesson. By contrast, in whole class teaching with the IWB – and generally – there is often an emphasis on simply exchanging and comparing ideas (Alexander, 2008; Serret & Harrison, 2007). As illustrated in some of the selected examples and video clips, it requires a skilled teacher to guide the enquiry. This often emphasises building up sophisticated understanding of a process, for example in our studies, photosynthesis, the genre of crime writing, or developing perspectives on trench warfare. The latter is now illustrated through a foray into one dialogic history classroom. The case study illustrates how the IWB 'flipchart' (a sequence of screens created in one file using the proprietary software), tools and resources can be employed to create a composite, evolving representation of knowledge that is not temporally located nor necessarily permanently

crystallised. Rather it is the interim sum of (ongoing) dialogic experiences over time: initially shaped through teacher anticipation of its future context of usage and then continuing to evolve.

EXAMPLE FROM SECONDARY HISTORY

In this study of three lessons (described in more detail by Mercer, Hennessy, & Warwick, 2010) with a class of boys aged 12-13, in-depth collaborative exploration took place over time of the open-ended question: "Can we imagine the experience of trench warfare?" The teacher, Lloyd, employed a wide range of multimedia resources, beginning with whole class interpretation of an army doctor's 1914 diary text. One boy used the IWB underlining tool to identify key phrases in the text and the class was asked to explain his choices, another example of built-in responsivity. The teacher then used the 'cover and reveal' facility to focus attention on selected segments of a graphic Wilfred Owen poem ('Dulce et Decorum est'). IWB activities were interspersed with pair and class discussions (as elaborated by Hennessy, in preparation), and short dramatisations of one segment of the poem by students and teacher, comparing their different interpretations. Further IWB resources structuring the activities included separate audio and video tracks of a single trench warfare film, a scanned textbook trench diagram, and photographs. These resources collectively embodied diverse experiences of life in the trenches. In turn they shaped the ebb and flow of the dialogic space through conjuring up spectrums of different perspectives – those held by their creators, by their subjects (soldiers) and those subsequently developed by the learners (which may or may not have overlapped with the others'). Lloyd's use of the multi-faceted IWB resources could hence be construed as drawing students into a space (or series of spaces) of dialogue across difference, where the various perspectives were in constant interaction, becoming salient sometimes in sequence (during or across lessons) and sometimes at once. (The compilation Video Clip 2 illustrates some of the activity during these two lessons.)

The lesson sequence culminated not in a common view of that subject matter, but in a rich, teacher-mediated dialogue between learners which drew on their experiences of the digital resources encountered and interacted with. The class discussion in the third lesson followed talk in pairs and synthesised students' evolving views about how far historians can extrapolate from using such sources and from partial experience, and how convergent their thinking can realistically be. An extract with some commentary alongside is presented in Table 1.

Table 1 approximately here

This discussion offers a powerful example of dialogic reasoning and meaning making, and of learners' metacognitive reflection supported by the teacher and by IWB use. This episode resonates with the notions of 'collaborative metacognition' and 'collaborative insight' described by Dooley (2009, 2010). These were facilitated by both use of provisional language and stability of children's ideas when represented on a rolling blackboard in the context of whole class mathematical conversation. The dialogue demonstrates that Lloyd's use of such a rich range of resources helped students to forge their own connections between the different perspectives embodied in the resources and in their peers' oral contributions, as well as to maintain their engagement. Littleton et al. (2010, p.138) likewise postulate that using multiple repetitions across semiotic domains renders these engaging and challenging rather than boring and patronising. The measured and respectful nature of the dialogue could also be interpreted in terms of Wegerif et al.'s (2010, p.615)

description (of electronic discussions) as "listening to different perspectives in a way that allows for the emergence of creative new perspectives (insights) that expand the dialogue without necessarily being a resolution to any problem". Here the dialogue is progressively broadened and deepened as the differences between perspectives are clarified and the boys are skillfully drawn into ultimately reflecting on the overarching process of dialogic co-enquiry itself. They move beyond the original question posed; Lloyd later considered that the students' responses had exceeded his expectations.

Figures 5 & 6

Note that the artefact created during this class discussion – notes recorded by the teacher on the IWB (Figure 5) – was a relatively impoverished representation of the thinking going on. It successfully served the purposes of focusing students on the question, summarising succinctly the key points being made in response, and facilitating further linking between them. Yet it could not capture the depth of analysis and responsivity that the natural language discussion portrayed. By contrast, a trench diagram (Figure 6) was drawn (side-on view) later in the same lesson by six students in turn each cumulatively adding elements perceived to be typically present. It comprised an imaginative range of such elements and succinctly portrayed rather more than was stated verbally. Talk was minimal during the drawing and merely served to identify the nature or origin of the artefacts depicted; this collective symbolic representation was instead 'drawn into being' (cf. Floriani, 1993). These artefacts and the dialogue depicted in Table 1 encapsulated much of the rich multimodal experience and pair/class dialogue of the previous lessons, with intertextual referencing by students to earlier digital resources: "building on their informed speculation from some of the things that they had seen" (Lloyd).

The case study serves to demonstrate how the teacher mediated the cumulative interaction with the IWB to support progressive discourse. The piecemeal, graphical construction of the joint artefact illustrates learner agency in the process of constructing and modifying meaning (Gee & Green, 1998). We can see how this process – likewise the activity over the three lessons – encompasses an ongoing interaction between individual expertise and common knowledge. It is also evident that the teacher's employment of such an imaginative mix of resources and linked activities served to engage all of the learners in the class despite the inevitably limited opportunities for their direct manipulation at the board during any one lesson. His own responsivity and skill in managing a cumulative and exploratory dialogue with a whole class, immediately drawing links between perspectives, are evident in the dialogue in Table 1.

4.3 Revisiting

4.3.1 Supporting intertextuality through revisiting

The IWB offers the facility to display several screens in turn and uniquely to archive a sequence of screens, including any alterations to them. It offers a physical, *permanent* record of collaborative activity that can be usefully *revisited,* referenced or modified during subsequent activity, soon after or much later in time. This material permanence of form helps to underpin "the recursive reflection and revision that is so important a characteristic of knowledge building" (Wells, 1999, p.116). Nondigital artefacts such as written texts, sketches, maps and diagrams can play a similar role of course but are less malleable or accessible by a whole class. By embodying the decision making, interpretations and progress made, digital artefacts can be argued to provide a focus for 'progressive

discourse' (Bereiter, 2002) across lessons as well as within. In particular, providing easier access to earlier representations supports the process of intertextuality.

In Bakhtin's account, the meanings emerging through interaction reflect the different past experiences and frames of reference that each participant brings, as well as the immediately preceding utterances. Students responding to the demands of dialogic enquiry must therefore reconstruct their view of the past (Kumpulainen & Lipponen, 2010, p56). This is challenging when oral texts are normally transient as previously mentioned, and it is particularly difficult to maintain fluency in all of the open-ended threads in a discussion lasting several weeks (Feito, 2007). The functionality of the IWB tool affords a far greater stability associated with the continued visibility of representations (until their purpose has been served and changes have been discarded: Twiner, et al., 2010). These representations serve the functions of recording and summarising, and of 'reigniting' prior cognitive reasoning as well as the 'epistemic' function of use as a tool for thinking and developing and refining understanding through dialogue (Feito, 2007).

At its simplest, this can mean revisiting with a class digital resources that teachers themselves have created in advance. For example a graphical representation of the equation of photosynthesis (Figure 7) was progressively built up – and earlier elements constantly revisited – over 6 lessons in one case study, as detailed by Hennessy, Deaney and Tooley (2010).[vi] Accompanied by practical investigation, this pivotal use of the equation structured the activities and helped students to explore and understand the role of each core element in the overall process.

Figure 7 approximately here
Figure 8 approximately here

Another example illustrates how the primary teacher devised an activity in which groups of children revisited a collection of images she had collated during the previous lesson, pertaining to personal safety issues and in particular the scenario depicted in Figure 1. A student from each group came up in turn to the IWB to annotate, sharing the advice they had generated during group discussions ("as a team working for Childline") and recorded on large sheets of paper (see an example in Figure 8). The teacher helped to make the dialogue cumulative between lessons and within the session by first preparing the image collection and then prompting students about the emerging contributions with open-ended, probing questions such as *Why did Mehmet write "be assertive"?"Why are you [suggesting she calls the] police?" "Does anyone agree that's a good step to take?"* She thereby helped children to be responsive and build on each other's ideas. Her sensitive mediation spawned a number of thoughtful ideas, reasoned arguments and mature insights into the characters' mindsets as the class together explored some complex issues and ethical dilemmas (e.g. the worry that a family would be split up if a domestic violence situation was reported); this is illustrated in Video Clip 3.

Alternatively co-constructed artefacts may be revisited. The first two annotated slides shown in Figure 2 were returned to in the subsequent lesson, reportedly in order to bridge between lessons. This revisiting pulled together ideas from the two poems studied and refocused students, allowing them constant reference to their earlier ideas and thoughts. These aides memoires reminded learners of what they already knew and provided a springboard for further discussion of the themes depicted. *Indirect* reference to resources or artefacts on the IWB includes our observations of the same teacher's unobtrusive display of a series of flipchart slides containing questions, suggestions and

previously viewed or annotated stimulus images linked to three poems studied over a school term, and excerpts from them (see Figure 9).

These fragmented but evocative representations of the poem again acted as prompts or aides memoires, reigniting collective interpretations of the themes and characters, and being made available for optional consultation while students were drafting their own poems; the teacher called this 'silent scaffolding' (Hennessy & Deaney, 2009). Both of these examples were *teacher-initiated revisiting* that clearly depended on significant advance preparation in collating previous resources, and in the second case, generating new forms of prompting to overlay (both on screen and verbally). In another recent study of IWB use in a middle school English classroom, many *students* asked for slides depicting typical crime story structures and adaptations from an earlier lesson to be displayed again in order to support development of their own crime stories. In the history lesson sequence outlined above students also requested access to earlier resources:

> When we were writing our piece on WW1 we had everything on the IWB and we were constantly going up and flicking through it. (Danny)

Likewise, Paavola and Hakkarainen observed how the activities of participants in the Knowledge Forum learning environment are strongly organised around the knowledge artefacts they are creating and have already created. In the 'Artifacts' project, "whenever students started to investigate a topic, they opened up corresponding shared views of the database and used those to guide and constrain their enquiry. Even classroom discussions were organised around a shared screen" (Paavola & Hakkarainen, 2005, p.551). Despite their shared ownership, IWB artefacts are usually less accessible after the lesson to students than to teachers (gatekeepers), however. The use of the IWB as a potential repository of resources or artefacts for student access is underdeveloped, perhaps for logistical reasons. Our primary teacher pointed out that in principle students could go and listen again to her audio recording of the personal safety text; she had previously encouraged their return to stored webpages, vocabulary and images (but not sound files). This constitutes another form of revisiting – continuing a dialogue within students' personal learning spaces.

In all of these kinds of revisiting, digital artefacts, like other produced texts, become "academically and socially significant resources for future work" (Green, et al., 2008, p.126). They constitute rich referential resources for the continuing dialogue, and this is not restricted to class discussion. We could construe learners' re-use of co-constructed artefacts in a new context as a form of *internal dialogue* that perpetuates and builds upon earlier whole class dialogue (conducted within the same or a previous lesson). Revisiting can scaffold learners' subsequent sense-making conversations – both external and internal ones. This iterative process includes making salient the difference or agreement between perspectives, hence creating another subject for discussion or reflection. Howe's (2010) research confirms that differences typically trigger references to conceptual material, sometimes that derived from earlier problems. Such references are linked with construction of superior frameworks and improved post-test performance. It would be useful to explore empirically whether exploiting the revisiting affordance of the IWB, initiated by either teachers or students seeking to make references back to earlier ideas, solutions or learning experiences, supports this kind of conceptual change through dialogic resolution.

Extrapolating again from research on nondigital texts suggests that revisiting screens instantly invokes the previous context in which an artefact was constructed, including any differences in interpretations and understanding, and this shapes the context currently being constructed (Floriani, 1993, p.257). Invoking prior contexts means invoking not just texts but social and discursive practices and "us[ing] the past to shape the future" (ibid., p.259). Could using the IWB offer a powerfully suggestive, additional resource for Floriani's notion of establishing a "dialogue between past and present texts" (ibid.)? Certainly the interrelationships between different modes of dialogue, occurring within different classroom spaces (e.g. in groups at tables or at the IWB at the front) and both synchronously within a lesson event and asynchronously over lessons, have implications for us as researchers seeking insight into the knowledge-building process. The inter-connectedness of classroom events embedded within the larger cycles of related activity found in most classrooms confirms the importance of access to – and iterative, analytical consideration of – the full range of interactions over time (Mercer, 2008). That is, understanding what was accomplished in any one episode or lesson requires an understanding of how the teacher purposefully created intertextual relationships with students and of the different responses from students as they made sense of the activities collectively and individually, negotiating common knowledge (Edwards & Mercer, 1987).

4.3.2 Revisiting digital artefacts created by others

Cole and Engestrom (1993, p.14) suggest that the subjective aspect of artefacts can be seen in terms of the "cognitive residue of prior actions crystallised in the object." This includes both residues from classroom activity, and knowledge that has been recreated and revised by humans many times before. The latter knowledge embodies what is more widely known in the discipline but also mediates knowing in action in new situations of application (Wells, 1999, ch.3) such as the classroom. Digital artefacts, again like utterances, are shared resources that can later be drawn upon or transformed by new communicators in new dialogues. 'Revisiting' may therefore be extended to include interacting with digital artefacts created by experts in the substantive area or by other groups of learners, for various purposes – perhaps as scaffolding, as a stimulus to provoke thinking and make explicit learners' own views in response, or again to explore difference between perspectives across groups as well as within. For example, we observed our history teacher display a spider diagram depicting a brainstorm from another class about "how wars start" for comparison and contrast with current conceptions. This strategy enlarges the learning community by allowing teachers and students to provide resources for different cohorts or generations.

In the same way that words carry with them the voices of those who have used them before (Bakhtin, 1981, p.924) and become one's own only when appropriated and adapted, displaying and commenting on previous groups' digital representations as in our example does not invoke the original dialogue nor allow access to an earlier dialogic space. Since meanings do not exist independently of dialogue, the use of a co-constructed artefact within its original setting, and its meaning to other learners subsequently interacting with it, will differ. In this view new ideas and interpretations continue to arise out of difference (Wegerif, 2008). By contrast, revisiting by the same learners may extend and develop a dialogue over time.

5. LEARNING OUTCOMES OF IWB-MEDIATED CLASSROOM DIALOGUE

This section considers the potential outcomes of the kinds of technology-supported dialogic teaching described throughout the paper; as educators our primary concern is of course with learning. According to Wegerif (2007), the voices interacting within an ongoing dialogue include artefacts themselves. As with other emerging views of technology itself as a participant in classroom interaction (e.g. Kennewell, Beauchamp, Jones, & Tanner, 2009), caution must be exercised in interpreting such phrasing in order to avoid the danger of erroneously attributing agency or autonomy: as indicated earlier these belong to teachers and learners while technology is only ever a passive 'participant'. A helpfully succinct description that explicitly focuses on the *process* rather than products of dialogue and resonates with my view of dialogic interaction with digital artefacts on the IWB as it has unfolded in this paper, is

> Cognitive artefacts, tools, poems, plays, pictures and so on, sediment and embody a perspective or voice on the world in a way that can be shared and taken up in new ways in new dialogues across space and time. Although they have an aspect as objects in physical space their meaning is given within dialogic space … it is intrinsic to their nature that they are many things at once. (Wegerif, 2007, p.279)

Wegerif explicitly plays down the role of producing artefacts in those contexts where induction into open-ended dialogic enquiry is itself the aim. He asserts that increasing awareness of the process (a form of deepening, as intimated above) and capacity for reflective and creative thought is the aim of "dialogue across difference". Stated learning objectives for a given classroom activity may not in fact encompass this notion of dialogue as a goal in itself, although arguably they should include learning to think and to learn. Our observations of IWB use have illustrated how employing rich multimedia resources and collectively producing new artefacts can be particularly effective in supporting the process of learners re-evaluating their own thinking and broadening their understanding in new directions – as already evidenced in the dialogue in Table 1. There the 'collaborative metacognition' (Dooley, 2010) skillfully supported by the teacher demonstrated generalisation and reflective thinking about the process of dialogic co-enquiry. Indeed the nature of the artefact is often less important than the intersubjective process of creating it, and its utility may in any case be short-lived. IWB artefacts can constitute a dynamic form of scaffold for thinking, and as the earlier discussion on provisionality and improvability implies, they are often needed only for certain stages of activity, after which support can be faded.

In the real world of schooling, most of the teaching and learning is shaped to some extent by the prevailing curriculum and assessment frameworks, and these tend to combine content and process objectives. The latter often explicitly or implicitly encompass skills for dialogue and – particularly in science education where theories may be compared and evaluated – skills for argumentation (e.g. Erduran, Simon, & Osborne, 2004) and enquiry. In history, Lloyd defined his 'second order' or process learning objective as developing the ability to see that people hold different views on things – in other words as becoming more dialogic. He also posed the question of what students are learning through dialogue:

> I'm not sure where we capture that. . . .We almost dismiss it, and it's what comes later on when they write something [individually] that's [deemed] more significant. . . .because we've been brought up in a particular context of education which values the outcome at the end. I think I'm guilty of this as well, that if they haven't written it down, almost I can't believe they know it! But hopefully, I bet they do, and they could tell me.

Lloyd raises a crucial and perplexing issue here, one which is rarely problematised in the literature, including within the trialogical approach: is dialogue truly an end in itself or is something else ultimately appropriated by individuals and collectively? Critical reasoning skills are one potential, often desired and measurable outcome (Dawes, Mercer, & Wegerif, 2004; Vygotsky, 1978), yet do participants subsequently come to develop any substantive disciplinary knowledge or new creative ideas?

There is a strong consensus view emerging amongst the key researchers in this field (see the collection edited by Littleton & Howe, 2010) that academic success is partly related to the quality of educational dialogues, but the ways in which that success is measured are diverse. The literature indicates that dialogic teaching approaches can serve as a vehicle for fostering development of substantive knowledge in addition to dialogue and reflective thought. A series of studies has shown that exploratory talk training as in the 'Thinking Together' approach (Dawes, et al., 2004) stimulates *both* development of (individual and group) reasoning skills plus learning gains in mathematics and science at primary level (Mercer, et al., 2004; Mercer & Sams, 2006; Rojas-Drummond, Littleton, Hernández, & Zúñiga, 2010; Wegerif, Mercer, & Dawes, 1999). Mexican research demonstrates generalisable oracy and literacy gains through collaborative writing in which learners 'blend their voices' and blend existent texts with new ones (intertextuality), through iterative cycles of action and reflection (Rojas-Drummond, et al., 2010). Scott et al. (2010) have further illustrated how dialogic pedagogy supports the meaningful learning of scientific concepts. Opening up a dialogic space is considered fruitful at least in topic areas where 'intellectual tension' between ideas is likely to arise, that is, when learning demands (Leach & Scott, 2002) are high.

The aforementioned work of Rojas-Drummond et al. (2010) introduces an interesting degree of complexity, however. In their studies, activity was characterised by exploratory talk when collaboratively writing argumentative texts, and in other cases (divergent tasks where there is not one solution and where differences of perspective are not necessarily manifested) by 'co-constructive' talk. The latter is similar except that children do *not* make their reasoning and argumentation explicit. In this talk, children may be proposing ideas and questioning and they "typically chain, integrate, elaborate and/or reformulate each other's contributions to negotiate meanings and jointly construct solutions to problems, including differences of perspectives" (ibid., p.135). 'Co-constructive' talk might be construed as having multimodal manifestations when the IWB is used; in particular the Mexican research indicates that creative brainstorming tasks, to which the IWB is eminently well-suited (e.g. Figure 2) may be less conducive to reasoning. Access to physical representations may in general reduce the need to make reasoning verbally explicit, as demonstrated in the studies by Murphy et al. (2010) of young children's collaboration on open-ended written arithmetic tasks after exploratory talk training. An example from our own data is the very concise talk-in-action by learners simply describing their additions to the trench diagram drawn on the IWB (Figure 6), e.g. "people kneeling down at the sides of the ditch", "sandbags" etc. There was only one, brief explicit explanation: "In the movie [intertextuality] you saw that sort of periscope-type thing that you looked over the top of the trench with, so that would probably be there." The rich graphic representation of students' perspectives on trench warfare during this third lesson of the series was itself 'co-constructive' and chained, obviating the need for fuller talk.

We can conclude that purpose is all-important and high quality dialogue can involve 'exploratory' and/or 'co-constructive' kinds of talk and activity; it does not necessarily involve making reasoning explicit nor converging upon a 'correct' representation, a solution or consensus view. Instead dialogue aims to augment understanding with new perspectives (Wegerif, 2010a), although not necessarily with immediate effect. As discussed above, the research by Howe et al. (1992) indicates that learning involves private construction of conceptions some time after group interaction, rather than internalisation of jointly constructed conceptions, and in certain cases a 'period of incubation' (Dooley, 2010) may be fruitful.

However we know that both learners and teachers *can* change their views soon afterwards to accommodate new ideas or take on some aspects of a collectively generated representation, as in the trench drawing example, where one student later reported:

> We've all drawn our own pictures of the trench, kind of like everyone's got their own view, and then through the IWB everyone's building a communal view of the trench . . . and then we looked at what the book said.

After joint reflection on this episode, two students asserted that they would use "quite a lot of the other people's ideas" if drawing another trench themselves. One stated:

> It would be kind of a mix because I put barely any people in mine originally. I had one guy standing with a rifle and then everyone was like, "oh put more people in". And like the water and everything, it is totally different to what I put.

The teacher also thought his representation would change:

> I would now think more about a side-on view of a trench; I'd think more about that than I would about the textbook [diagram]. . . because it's made quite an impression on me.

These quotes confirm the impact on individual thinking of progressively negotiating a communal representation. This itself made explicit and democratically brought together multiple ideas based partly on shared experience of exposure to digital resources in an activity context where learners controlled the stylus and picture content entirely, with no teacher input.

More research is needed into this complex area though, as the degree and stimuli for change seem to vary enormously according to individual perspective, prior experience, motivation and receptiveness to new ideas, as one of Lloyd's students described:

> I find sometimes people just bring their own ideas. People like Tim. . . Then there are people like Jack. He'll just take the discussion we've had and just form his own view from the discussion instead of using his own knowledge from before.

Mercer (2000, p.172) confirms that by bringing different contextualising resources to the task of making sense of experience, "individuals can add to the richness of the collective intellect"; both teacher and learners contribute here. An example is a science teacher relaying examples of previous students' personal, nonverbal representations illustrating how the plant cell wall protects and supports: these drawings had reportedly depicted hitting a brick wall with a fist or car bashing into it and bouncing off as the cell wall flexed. (The teacher sketched only a rough brick wall on the IWB whilst explaining this verbally). These representations were 'repurposed' (rather than revisited directly) and used as scaffolding for his subsequent class, stimulating a variety of new drawings in

exercise books (aides-memoires for the originators: Hennessy, et al., 2010). A few of these were then drawn freehand onto the IWB or projected there using a flexible camera (form of visualiser) and publicly explained by pupils. Some representations in books were quite evidently based on the original students' ideas or on peers' ideas shared via the IWB while others were new perspectives (e.g. the cell wall protects a football player from a ball kicked towards him as in Figure 10, the drawing adjacent to "Cell wall").

Figure 10 approximately here

What is certain is that there is no simplistic input-output mechanism for learning through dialogue. Moreover, 'cumulative' and 'progressive' do not imply a straightforward linear trajectory of learning (Twiner, et al., 2010) nor a common final product. In contrast, a trialogical approach to e-learning (Tzitzikas, et al., 2006) within the Knowledge-Practices Laboratory (K-P Lab) assumes that community interactions and development of new knowledge artefacts merely involve union or intersection of individual knowledge bases. Rather, the ultimate outcome may be far 'more than the sum of its parts.' Encouragement for this position comes from observations by Hershkowitz et al. (2006) of dyads and triads solving mathematical problems which indicated that collective construction may have been richer than might have been the case for the individual partners yet individuals had unique methods of constructing a solution. The latter evolved from different needs at different points in time, and constructs of individuals within the group varied accordingly.

In the earlier examples of cumulative dialogue episodes at the IWB observed in our studies (e.g. building up a food chain), responsive actions typically comprised kinaesthetic interactions with the board accompanied by brief spoken explanations of rationale. They yielded some significant outcomes in the form of collectively produced objects – represented mentally as well as digitally. These embodied new or refined, more complex knowledge structures that were open to appropriation by individuals both during and following the process of meaning making. Different individuals may well appropriate different aspects of a collective representation, or be stimulated to later reflect on and revise their own conceptions in a new direction, in response to encountering those of other learners.

We can conclude that the products of dialogic activity may comprise
   (a) dialogue, reasoning and enquiry skills themselves (if pedagogy is supportive); it is probably necessary to develop these in teachers and learners before expecting them to use the IWB in genuinely interactive ways in whole class settings – either explicitly as in the 'Thinking Together' approach (Dawes, et al., 2004) and as observed in our primary and middle school dialogic classrooms, or implicitly through modelling them as our secondary history teacher did;

   (b) appreciation of different perspectives on a topic, including those of peers, teacher and sometimes experts (eg scientific theories) coupled with either a consensus view, a collection of ideas or an agreement to differ (differences will be more apparent with convergent rather than divergent tasks: Rojas-Drummond, et al., 2010);

   (c) fluid forms of content and process knowledge that are both individual and shared, internally and externally represented, and situated within the dialogue itself, whilst evolving further

through dialogue as it continues over time, internally (dialogic reflection) if not interpersonally.

To reiterate, the primary products are thus not the material digital artefacts themselves, although these may constitute a powerful, re-useable and multimodal form of external knowledge representation – albeit in new contexts and for new purposes. More significantly, these may usefully embody some of the thinking to date and reify the dialogue associated with their construction. Hence they are subsequently useful not only to learners but perhaps to teachers or researchers interested in assessing what has been learned: a thorny issue. How can we know what change has taken place within a group of learners, what measurement techniques can we use, and how long after dialogic interaction should we investigate this? As the discussion on revisiting indicated, artefacts do not form a direct conduit to a learner's understanding (Roschelle, 1996) so by themselves offer us only limited insight. Other attempts at direct introspection into cognitive representations are not feasible either (without influencing the representations of interest). Observational data may be unreliable too since apparently passive students may in fact be engaged in internal dialogue.

The model of distributed cognition (Salomon, 1993) in which culturally shared models are not stored in any single person's head but are distributed (either physically or socially) across the different sorts of expertise and viewpoints found in a group, has some resonance with the account being developed here, and some implications concerning outcomes. In particular, it similarly asserts that cognition develops contingently upon others' responses, assisted by (evolving) cultural tools acting as mediating artefacts. The theory highlights the difficulties, though, of even identifying the level of divergence in thinking, and of knowing what others who are not articulating their thinking have previously experienced, conceptualised or appropriated and how this is currently shaping their personal interpretations.

Recordings in exercise books and subsequent interview responses can shed some light. In our studies these tended to indicate that learners (and teachers) perceived digital artefacts non-uniformly and made use of them to varying degrees and in various ways, as they might with other artefacts. Mavers (2009) addresses this in her compelling account of how primary children focused on different aspects of a resource and reversioned texts for their own purposes when recording personal representations, even when 'copying' from a board or book; this involved making shifts in meaning in the course of doing important "semiotic work." Hay's (2008) work on dialogical concept mapping, along with successful employment of the stimulated recall interview technique in research studies in this area (eg Wegerif, et al., 2010), indicates that using digital artefacts as stimuli for discussion with or between students about their learning – either during a lesson or some time afterwards – may be a fruitful form of formative or summative assessment. Comparing artefacts such as concept maps produced at the beginning and end of a lesson sequence as did one primary teacher observed by Kleine Staarman (personal communication) powerfully illustrates to learners themselves how their thinking has moved on.

Finally, while co-constructed digital artefacts play a critical supportive role in classroom dialogue, most are physically abandoned as the class ultimately moves on to other topics. But the dialogue and the thinking may of course continue in some form or another, beyond the production of specific knowledge artefacts and beyond the boundaries of the school setting – in spaces and ways that we

cannot possibly capture. For example when, in their future lives, the students in the history class encounter other accounts of warfare, we might expect their responses to be influenced by the meanings created within their classroom dialogue. Likewise, when they go on to study other topics within school, their experience of processes of enquiry, dialogic interaction, role play, interpretation of historical artefacts, extrapolation from specific situations, as well as their metacognitive reflections on all of those processes, may well continue. And of course, new goals, problems, mediational means, perceptions and interactions inevitably arise in new situations, shaping new dialogues and meanings. Note that this lack of either containment or concrete product is a key feature of successful learning in formal educational settings. It means that bounded models such as activity systems offer limited value in understanding the complexities of learning in a dialogic classroom; genuine dialogue will not confine itself to the 50-minute lesson, the serendipitous grouping of 30 students of a similar age, or the space within four classroom walls. In sum, digital artefacts have a varying but limited shelf life, and the outcomes of drawing learners into dialogue are far more than these.

6. CONCLUSIONS

The practices of working innovatively with knowledge become accessible to school children when … they are provided with advanced tools for creating and building knowledge based on the new information and communication technologies (Paavola & Hakkarainen, 2005, p.549).

I have argued that the IWB constitutes a powerful new form of such a cultural tool. Its particular affordances, including visibility, provisionality, stability, direct manipulation, multimodality and re-usability, potentially offer strong support for cumulative, collaborative and recursive learning. Its effective use by teachers can provide appropriate scaffolding to help make explicit and create knowledge, through opening up a (physical and cognitive) dialogic space in which new personal and shared meanings can be negotiated. This space is potentially productive for learning because (a) different ideas can more easily be juxtaposed, foregrounded, explored, connected, compared and contrasted, rendering strengths and weaknesses more salient, and (b) learners can jointly construct and interact with digital artefacts on the board. These external representations of conceptual and procedural knowledge and cultural information are the support for and the interim records of the creative process. They become rich, situated resources for a group, shaped by prior history and providing access to participants' interpretations and current understandings as well as to external others' ideas; they may incorporate multiple voices. At the same time they may help learners to differentiate between perspectives, supporting further joint reflection and synthesis. To conclude, artefacts could be said to act as staging posts and launching pads for evolving dialogues that are fluid and elastic as they continually leapfrog in new directions – sometimes circular – from provisional reifications in the artefact. They afford progression in learning through cumulative development of new shared understandings – both of curriculum content and the process of co-enquiry itself. Hence constructing digital artefacts, usually in conjunction with co-constructive talk, can serve to both broaden and deepen classroom dialogue.

To fully exploit the potential of the IWB requires further research into how different modes of representation and communication are privileged; how their affordances, constraints and degrees of use vary according to pedagogic purpose, nature of activity and teacher's familiarity with the IWB and its software; whether and how each mode makes a distinct contribution to shaping the kinds of

dialogue that ensue and the kinds of meaning that are made; how combining or layering modes can reshape domain knowledge, add value and communicate more complex meanings (as in McVee et al.'s 2008 study of digital composition using HyperStudio or digital video). Further work is needed to unpack the assumption that multimodality promotes learning, already questioned by Jewitt (2008), and to explore the increased demands on students. Mayer's (2001) research into multimedia learning portrays the benefits of multiple representations, especially text and animation, but learners must actively make and understand connections between them (Ainsworth, 1999), whilst avoiding cognitive overload, redundancy and split attention effects (Sweller, 1999). Our history teacher's isolation in turn of the soundtrack and the visual elements of the same DVD provides one exemplar on which more research might build; how useful are such pedagogical strategies ("less is more"?) and what might the teacher need to do in addition? Do such strategies – and the layering of modes – strategically focus learners' attention?

Finally, while use of the IWB is still emergent, new features, new forms (e.g. horizontal "tabletop" boards) and new technologies are inevitably springing up. As these tools and our uses of them evolve, new forms of dialogue will inevitably emerge. The pedagogical issues discussed here nevertheless remain pertinent if we want to harness the tools purposefully and successfully for classroom learning without merely being seduced by their technological glitz (Lankshear & Knobel, 2006). In fact our own and other research (Gillen, et al., 2008; Kennewell & Beauchamp, 2007) indicates that fairly prosaic uses of the IWB (e.g. displaying a question and recording students' responses around it) can actually be remarkably effective when a dialogic pedagogy is the driving force. So rather than starting with the technology and seeking to exploit its 'whizzy' features, teachers might join us in extending the enquiry into how patterns of interaction and activity already established in the dialogic classroom can be supported and enhanced by exploiting the unique combination of affordances of the IWB and its future incarnations in pedagogically principled ways.

A starting point might be the multimedia professional development resources we are creating to stimulate teachers' interest in exploring new dialogic approaches and reflecting on their own practice.[vii] The resources are co-authored with our partner practitioners and they communicate in accessible language the notion of dialogue developed above, along with its preconditions and some strategies to support it. Activities centre on the exemplars of practice in this article and others arising from our studies, illustrated by video clips, screenshots, teacher narratives, etc. The aim is to draw out from the above theoretical development of ideas some practical pointers for teachers wanting to exploit the technology in more interactive ways than is typically observed.

The author welcomes further dialogue with peers about these ideas.

SUPPLEMENTARY MATERIAL

The following supplementary material for this article is freely available online, hosted by the University of Cambridge Streaming Media Service:

Video Clip 1 (9 mins) at http://sms.cam.ac.uk/media/1085166, depicting students annotating a portrait of the young Queen Elizabeth I. This is also available as Clip 1.2 in the online history multimedia resource at http://t-media.educ.cam.ac.uk, where analytic commentary from participating teachers and researchers plus other supporting material can be found.

Video Clip 2 (2 mins) at http://sms.cam.ac.uk/media/1085205: a compilation of clips from two consecutive history lessons showing a student explaining his underlining within a war diary text on the IWB, another pair explaining at the IWB the video storyboard they have co-constructed and the class discussing the boys' ideas.

Video Clip 3 (10 mins) at http://sms.cam.ac.uk/media/1085308, illustrating students choosing and annotating images pertaining to a personal safety scenario, group report back and class discussion.

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i   The IWB is a system comprising a computer linked to a data projector and a large electronic board displaying the projected image. The touch-sensitive board allows direct input via finger or stylus so that objects can be easily manipulated or modified by teacher or students.

ii   The projects were all funded by the UK Economic and Social Research Council. They included SET-IT ("Situated Expertise in Technology-Integrated Teaching": R000239823) in 2002-2005 (with Kenneth Ruthven and Rosemary Deaney); T-MEDIA ("Teacher Mediation of Subject Learning with Technology: A Multimedia Approach": RES000230825) in 2005-2007 (with Rosemary Deaney), and the "IWBs and Dialogic Teaching" project undertaken in collaboration with Neil Mercer and Paul Warwick as part of a personal Research Fellowship programme of work carried out in 2007-2010 by the author (ref. RES063270081). Reports and publications from each are available at http://www.educ.cam.ac.uk/research/projects/istl/. The first two projects did not focus on dialogue but the themes emerging encompassed dialogic interaction and this stimulated further investigation.

iii   The T-MEDIA multimedia resources (see Hennessy & Deaney, 2007) are all freely available at http://t-media.educ.cam.ac.uk.

iv   The UK National Strategies for primary and lower secondary schooling include dialogue under "Speaking and Listening" skills, however definitions are inconsistent. They range in the same document (DfES, 2003) from "Speaking: to use and reflect on some ground rules for dialogue, e.g. making structured, extended contributions, speaking audibly, making meaning explicit and listening actively" (p.9) in Year 4 to "Speaking: to use techniques of dialogic talk to explore ideas, topics or issues, e.g. . . .using formal language and spoken standard English" (p.11) in Year 6.

Syllabi and standardised examinations at age 16 are reportedly undergoing the biggest shake-up for 20 years and will include stimulus questions such as "why do people become terrorists?" (history). Geography, science and citizenship are further areas where controversial topics are already discussed and a move for philosophy in schools directly targets reasoning and evaluation skills.

v   Vygotsky's dialectic perspective and Engestrom's expansion of Activity Theory both assert that learning is stimulated by prior inner contradictions (Wegerif, 2008).

vi   Video illustrations of how the equation was built up over time and how the teacher managed and structured the activities surrounding it can be seen on the T-MEDIA multimedia science resource at http://t-media.educ.cam.ac.uk (see Clips 1.3, 2.3. 4.2, 5.1).

vii   The resources are currently under development; they are freely available via our website at http://dialogueiwb.educ.cam.ac.uk/.