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Instruction as orchestration: multimodal connection-building with the Interactive

Whiteboard

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Abstract

The Interactive Whiteboard (IWB), the first ICT tool primarily designed for whole-class interaction, is now in regular use in most British primary schools. In this paper we explore its distinctive potential for enabling the teacher to plan and orchestrate activities and lessons using a wide range of multimodal resources, to engage students' cognitive and imaginative capacities. We show how teachers use combinations of "matched resources" to support the bridging of pupils' understanding from the known to the new, and from everyday to academic understandings. We demonstrate how teachers can use the IWB to resource the development of ideas and themes over time while maintaining spontaneous responsiveness to situations as they arise, effectively enacting Sawyer's (2004) notion of teaching as "disciplined improvisational performance".

Our aim in this paper is to understand the ways in which diverse semiotic resources, including those facilitated by the use of the interactive whiteboard (IWB), are harnessed by the teachers to build connections (Gee & Green, 1998) between events and ideas. With Gee (2007), we believe that such connection building is always a situated endeavour, drawing from and contributing to particular interpersonal, institutional and cultural-historic contexts. Meaning is thus always constituted within the context of semiotic domains - combinations of resources in particular modalities associated with specific, situated practices (Gee 2003).

One of the critical functions of classroom interaction is connection building and from the pupil's perspective, school-work should ideally have a cohesive, cumulative quality in which specific activities and their goals can be seen to form part of a greater whole - a purposeful educational journey. That said, coherent knowledge and purposeful understanding will not naturally emerge for students simply from their continuous immersion in classroom life: it has to be pursued actively through the use of appropriate teaching strategies (Mercer & Littleton, 2007) whereby particular activities are aligned to broader goals (Lemke, 2001). A central educational challenge then, is to ensure that the talk and joint activity that occurs in classroom contexts is cumulative, rather than merely extended (Alexander, 2000; 2008), and harnesses the full range of modes of meaning making appropriate to the semiotic domain (i.e. writing, images, gesture, speech, sound). We term the aspect of the teacher's response to this key educational challenge, as studied here in connection with the use of the IWB, the 'multimodal orchestration of resources'. In doing so, we build on the work of Bourne and Jewitt (2003) who in characterising 'multimodal orchestration' drew attention to the ways in which learning and teaching take place through the complex interplay of a range of modes (which we define as organized sets of semiotic

resources for meaning making that instantiate the work of culture and social usage, see Jewitt, in press). The concept of orchestration as highly relevant to the conduct of successful dialogic teaching has been raised in educational literature in the past (e.g. Green & Smith 1983; Wood, 1998, p.98 as discussed by Kennewell, Tanner, Jones & Beauchamp, 2008) and has been pre-figured in the notion of 'teaching as improvisational performance' by Sawyer (2004) as discussed below. In this paper we will suggest that this metaphor is particularly helpful when discussing the classroom environment enriched by the IWB in the hands of a skilled teacher. The term orchestration conveys the way in which the teacher channels the focus of attention towards a specific aspect of an ongoing activity. S/he conducts moment-by-moment shifts between what is foregrounded and what is backgrounded, taking into consideration the contributions of children.

Any such channelling is necessarily multimodal: "Situated communication always involves multiple dimensions and modalities of meaning making, some simultaneous and others playing complementary roles at different points in achieving the overall goals of the activity" (Wells, 1999, p.116). In this paper we endeavour to pursue the materiality and dynamic synergies of modes in educational interactions, analysing the ways in which the teachers studied here pursue the pedagogic goals of connection building and cumulation of purposeful understanding by orchestrating multimodal resources, including those constituted through the use of the IWB.

First we explore how connections are made to previous and anticipated future interactions and activities in the ongoing, emergent trajectory of meaning making (Baldry & Thibault, 2006) in the classroom. Second we examine how teachers and students "choose from, engage with, and in the process transform, the representational and communicational affordances…of all the modes available to them in the

classroom" (Bourne & Jewitt, 2003, p.71). Third, we focus on how teachers bridge (Rogoff, 1990) pupils' understandings from the known to the new and from the everyday to the academic and how this bridging is accomplished through a multiplicity of semiotic resources. Fourth we make reference to how unanticipated contributions from pupils may be woven into the ongoing patterns of communication. We note here that these four foci are not presented as analytically divorced from one another; we find that the use of the overarching concept of 'orchestration of resources' is useful in capturing the entwined nature of the processes studied here. Accordingly our discussion focuses on each issue singly in the context of the class with the roles of the other three foci remaining present, albeit in the background. The final example brings back into view the interrelationship between these four foci.

Our exploration of these issues draws on the detailed analyses of a series of classroom observations undertaken as part of a UK Economic and Social Research Council (ESRC) funded study concerning the use of Interactive Whiteboards (IWBs) as mediating tools in primary classrooms (Gillen, Kleine Staarman, Littleton, Mercer, & Twiner, 2007; Gillen, Littleton, Twiner, Kleine Staarman, & Mercer, 2008). IWBs were introduced into British primary schools extremely rapidly during the period from 2003 until 2006 (when data for this study was collected) and have continued to proliferate since. In 2004 63% of primary schools had at least one IWB; in 2005 the mean number of IWBs in primary schools was 5. (British Educational Communications and Technologies Agency: Becta 2005, 2006a; 2006b). At the time this study was carried out we were confident that virtually every school child in the UK had had some experience with them and that for many they have become an everyday presence.

The IWB, with its large, touch-sensitive display, is perhaps the only type of educational technology intrinsically designed for whole-class interaction. (Delving into their origins reveals business use, essentially of a presentational nature.) Typical functionalities of IWBs include:

1. A large, touch sensitive, full-colour display on which teacher and pupils can write their own text, call up text and images from their hard disk, internet or intranet and run a range of specifically designed curriculum-related software, including diagrams, simulations, partially completed 'quizzes' etc;

2. The option to select, display, move, manipulate and annotate images (including video) and texts;

3. The possibility to save and recall current and previous screens or elements of screens, which may be revisited, reviewed and amended as and when required;

4. The option of connecting the IWB to a range of other ICT equipment, including laptops operated by children in the class, digital cameras, video-players and microscopes.

Whiteboard use represents a particularly apposite context for researching multimodal orchestration and connection-building as research has suggested that one of the distinctive affordances of the IWB is that it enables teachers to construct and use a rich blend of diverse, multimodal resources (Kennewell & Higgins, 2007). Underpinning our analyses is a conception of teaching as a creative, disciplined improvisational accomplishment. As Sawyer (2004, p.12) notes: "conceiving of teaching as improvisation highlights the collaborative and emergent nature of effective classroom practice". In improvising the teacher: "creates a dialogue with the students, giving them freedom to creatively construct their own knowledge, while providing the elements of structure that effectively scaffold that co-constructive

process" (Sawyer, 2004, p.14). We are thus interested in the ways in which such structuring is accomplished as connections are built and pursued multimodally.

Data Collection and Approach to Analysis

Data presented in this paper come from in-depth classroom-based observations and semi-structured interviews with five teachers working with IWBs in urban primary (elementary) schools in the South of England. The classes were of children in Key Stage Two i.e. aged 7-11 years, at the upper end of primary education. Four teachers were video recorded during two sequences of two lessons, providing 16 lessons overall; the fifth teacher was recorded during two separate lessons only. These teachers were also interviewed to investigate their accounts of their use of IWBs within their classroom-based teaching and learning practices; other teachers from other schools who were particularly interested in using the IWB were also interviewed. The specific aim of the study, was to explore the (potential) contribution of the IWB to a dialogic approach to teaching and learning (see Alexander, 2008; Mercer & Littleton, 2007). Teachers participated in the project on the basis of their interest in the project and all had a relative degree of expertise with IWBs.

Analysis of the data involved repeated consideration of all recorded data and associated transcriptions in order to trace the ways in which the teachers' goals were pursued across the lessons, through all modalities present. The analysis thus involved an iterative process of moving backwards and forwards through time, trying to make sense of the episodes as linked chains of interactions. The exemplars we present below are not intended to be representative of the totality of lessons observed, but are rather used as vehicles for exploring the issues of interest outlined above. Where relevant, timings have been indicated in brackets. With this focus on how knowledge

is co-constructed using language and other semiotic resources, the presentation of findings and their discussion is necessarily interwoven.

Findings and Discussion

Connections to previous and anticipated future interactions and activities in the ongoing, emergent trajectory of meaning making

Teachers frequently work to establish connections between prior and current, on-going events by weaving subtle linkages into the multimodal fabric of the lesson. In one of our case-studies, for example, we observed a series of lessons on the theme of the Aztecs, which were taught by the teacher we will call Jane, a week apart. At the start of each of the lessons, as the children were initially entering the classroom and settling down to organise their books and worksheets, projected onto the whiteboard was a dynamic computer screen-saver displaying Aztec motifs. As the images moved around the screen, a soundtrack of traditional Mexican folk music played. Whilst a relatively simple device, it was evident that the repeated presence of this audio-visual display at the start of each Aztec lesson accomplished some initial (re)orientation and multi-sensory contextualising work for the teacher and pupils. Before she had actually said anything about the lesson context and content the teacher was indicating to the children, using both auditory and visual modalities, the broad topic area for the lesson. The repeated recurrence of this at the outset of each lesson came to be part of the way that the children understood that the Aztecs were the topic of the lesson.

In another of our case-studies, to prefigure a new activity in a science lesson, the teacher, Lucy, displayed photographs of a prior investigation on the IWB and involved pupils in moving the labels to the correct photographs. She also used photographs of pupils doing the experiment in a previous lesson (lesson 1) and of equipment used in the experiments (lessons 1 and 3), as an aide memoire of what they

had done previously. In lesson 3 there were particular ways in which Lucy used the affordances of the IWB to link representations of the apparatus with the scientific activity of predicting. For instance, at 17.00 (17 minutes into the lesson) there is a summary on the IWB of what they are about to do. Lucy explains the practical activity and asks some of the pupils questions concerning the experiment. Later (25.30) the IWB is used to support their write-up as the teacher draws on and labels a sample diagram of the apparatus. She then reveals text hidden by the 'screenshade' on the IWB (26.15) - with starter sentences the pupils are to complete to make their predictions of what will happen and why. Instructions in black are for copying (e.g. title), instructions in red are for pupils to complete themselves (diagram of apparatus). As the pupils continue to work (33.00) the teacher draws their attention momentarily, revealing the final hidden sentence that is to be completed by those pupils who have already finished the diagram and predictions. The start to the sentence, in black for copying and to be completed, is followed underneath by a red instruction to draw a diagram.

It is already apparent that for these teachers the process of making connections to previous and anticipated future phenomena, involved them in supporting the students to actively engage with the representations (Collins & Green, 1992). Thus the process of making links is not merely a matter of the teacher manipulating resources to be received passively, but rather in a broadly social-constructivist approach to bring the students into interaction with the objects. Recognising this, we now shift our focus to examine particularly the facilitation of engagement with and active take-up of resources.

Guided selection, engagement with and transformation of resources

We referred earlier to how, in making connections to previous lessons, Lucy displayed photographs and involved the pupils in moving labels. The particularly salient affordance of the IWB is that it is easy to display texts such as photographs and labels and then to interactively work with them. Lucy asked pupils to move the labels around to check their memory for and understanding of key concepts and ideas introduced in the previous lesson and also to annotate the photographs with 'open text'.

There were also occasions across the lessons where the teacher could be seen to use "matched resources" to support connection building (Hennessy & Deaney, 2006). Here material was displayed or referred to in one modality, and also in other complementary forms,. making the same or similar information accessible in different forms to establish linkages and support learner preference and learning style.

In reporting their work, Hennessy, Deaney, Ruthven and Winterbottom (2007) documented how: "the IWB contributes to the creation of a fluid 'shared communication space'" (p.284). They have also, however, emphasised the importance of the teacher's adaptability to pupils' needs by moving swiftly between IWB and non-IWB resources. Moss *et al*'s work (2007) supports this notion, in that they suggest that pupil interaction with the IWB can be motivating, but unless such use and materials are orchestrated successfully and appropriately to the pupils' technical and subject knowledge and skills, it will not automatically enhance their learning.

We observed one Year 5 Science lesson where pupils (age 9-10 years) were asked to draw and/or label teacher-produced diagrams of apparatus, and another instance later in the lesson where they filled in blanks in a flow diagram. In both of these cases the diagrams were presented on the IWB, so that the class could do a

worked example. The shared IWB and individual sheet combination also enabled them to collate responses once the pupils had completed their own sheets.

In another Year 5 Science class in a different school, the class were creating concept maps to illustrate the process of evaporation. The teacher, Nicola opened a file on the IWB with some pictures and labels (such as water, ice, water vapour, evaporates, melts) (lesson 2, 08.15). These matched a sheet of pictures and labels that pupils had been given in pairs. The teacher asked pupils to suggest a possible concept map using the pictures and labels they had in front of them and on the IWB. She was then able to move the IWB representations, adding in arrows from the IWB software tools as she did so to show direction of the process. This demonstration remained on the IWB as the pupils worked to produce their own examples of substances changing states from solid, liquid and gas on the sheets in front of them.

In both of these lessons we see that the resources presented via the IWB can be a stimulus for work done in class, matching information available in other tangible forms and in the form of class discussion or task instructions, as well as the basis for activity itself. A resource does not have to be fixed, but can be modified to best serve its current need within the IWB's functionalities, as determined by the teacher's response to pupil activity and input. By remaining on screen during individual activity, it can act as a reminder for pupils of the task to be done, and how to approach it. It can then become a collection point for work done individually and as a setting for a more informed discussion once the pupils have worked through the material themselves.

With reference to their own research in secondary science classrooms, Hennessy et al. (2007, p.297) remarked that: "use of individual printed copies of displayed IWB material for manipulation or annotation by all pupils increased their

active participation by providing a bridge between activity within the public arena and the private learning spaces." It could be argued that in providing such matched resources the two teachers observed and reported above were orchestrating a similar triangulation of resource and learning; through the combination of projected IWB displays, teacher and pupil manipulation of demonstrations and answers on the IWB, and individual or paired activity. All of these were joined together by continuous, cumulative and responsive discussion between teachers and pupils, and pupils amongst themselves.

When it comes to attempts to engage in sustained, cumulative knowledge building, spoken discourse has some particular limitations, and as Wells (1999) suggests: "Chief among these is the evanescence of the understandings achieved in speech…" (p.115). Recognising this, teachers often encourage children to either collectively or individually construct texts or representations which capture something of what has been said. Wells (1999) has suggested that such texts can serve as "improvable objects", and by this he means that such an object "provides the focus for progressive discourse and simultaneously embodies the progress made" (Wells, 1999, p.115). All forms of meaning making (including for example, diagrams, rough sketches, point-form or brainstorming notes) which give permanence to, or capture something from the ephemerality that is talk have the potential to serve as improvable objects. In each case: "It is the material permanence of the form in which the semiotic artefact is embodied that enables it to support the recursive reflection and revision that is so important a characteristic of knowledge building" (Wells, 1999, p.116).

Our observations suggest that the affordances of the IWB were frequently harnessed by teachers to engage pupils in the creation of texts which served as such improvable objects. The texts generated as part of this process were typically saved

onto the computer and became resources for iterative reflection, revisiting and re-versioning over time. We have selected an example of the creation of an improvable object from a Personal, Social and Health Education lesson.

FIGURE 1 HERE

Within this lesson, Jane had chosen a DVD extract to show the class (lesson 3a, 11.50). After watching it through once in full, she re-played it, pausing it at planned points to elicit comments from pupils and to ask them to annotate the frozen image on the IWB (see fig. 1). On both occasions the frozen frame was of a character's face, and pupils were asked to suggest words for how that particular character might be feeling, manipulating and developing the IWB resource accordingly. In this she used the IWB to foreground issues for consideration and discussion by the class. In this context 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. Key elements of the discussion had been collected and captured in this process which employed the IWB as a semiotic artefact. The improvement of the object is a material part of the trajectory of learning in the classroom, through remaining available as a tangible resource for further discussion, creating and capturing.

Building connections from known to new and everyday to academic: multimodal bridging

We now shift our focus to processes of bridging - from the known and everyday to more cognitively demanding or academic understandings making use of multimodal resources. "The process of communication, whether verbal or nonverbal, is a social activity that can be regarded as the bridge between one understanding of a

situation and another" (Rogoff, 1990, p.71). This communicative act assumes intersubjectivity, defined as: "shared understanding based on a common focus of attention and some shared presuppositions that form the ground for communication" (Ibid). Such attempts to build and build upon shared understanding, through use of the IWB and non-IWB resources, were apparent in our lesson observations.

In a Year 5 science lesson, Lucy introduced a "Science Keyword Bingo" game on the IWB, thus recruiting knowledge of bingo as a semiotic domain into the classroom. Possibly drawing on past experience, she appeared to know that she could rely on children possessing the necessary literacies to act with the distinct modalities and signs of bingo in this setting (pace Gee 2003). As children finish their previous task, they draw a 3x3 grid and insert their choice from among a set of words displayed on the IWB. All are words they have been using within the lesson. Some of these words have meaning in the everyday domain, such as salt, others are more restricted to the academic domain. Lucy is ingenious in her endeavours to bridge understandings through drawing attention to the polysemy of many relevant words. For example, she explains the rules of the game and says that when they have a winning row they should call out "solution". This, of course, is a word which in its everyday sense corresponds to 'answer' but she also takes the opportunity to check understanding of its scientific sense. She often refers to "reminding ourselves what they [words] mean." In the pursuit of this, she refers back in time, to discussions earlier in the lesson, to definitions already explored, to synonyms and examples. She conveys simultaneously a fact about language, that a word can be used in various contexts in everyday life and that with the alternate scientific discourse it is worth working hard to gain the precise meanings that enable understanding of its scientific salience and significance. She is conveying how the children learning science are

expected to think, value and interact with the "virtual identity" of "student as scientist" (Gee, 2003, p. 60).

So, these discursive strategies, where linkages are explicitly articulated and discussed, are in a dynamic interplay with others that are purposely designed to establish continuity and build linkages harnessing other modalities. It is also clear that not all the connections and linkages that teachers seek to establish are made verbally explicit or are commented upon.

Elsewhere Lucy explicitly explains why science uses buzz words with a list of technical terms presented on the IWB. As she sets up an experimental activity, she ensures the aim and method of what they are about to do are clear and then states: "while you're working there's something else I want you to do as well as that. I want you to use the equipment and to be able to talk about what you're doing using these buzz words." The way the instruction is worded is particularly noteworthy. "I want you to....and to be able to talk about.... " conveys her expectations of them and "to be able to…" draws attention to the notion that command of scientific discourse is as worthwhile as being able to do the experiment, to understand the phenomena. In this teacher's work they are all related to developing elements of the virtual identity of student as scientist. So her exhortation to the students to maximise their consciousness of the polysemy of many lexemes in the everyday domain, in addition to taking command of those solely with scientific meanings, is an exemplar of her skills in bridging connections from the everyday to the academic as well as moving from the known to the new. The teacher's role is thus crucial in helping students to integrate new information and representations within a wider scientific frame (Mortimer & Scott, 2003). The list of buzz words remains on the IWB as pupils work on and write up their practical experiments.

Following this, the class have their "science slot" (51.00), where pupils are selected to present their experiment, via webcam projected onto the IWB, to the rest of the class. Whilst pupils read their methods for the camera, the teacher asks the rest of the class to count how many buzz words they use in their method.

This is an example of where cognitive engagement in collaborative endeavour (Cole 1996) is facilitated by the teacher's orchestration of selected IWB functionalities within the whole class teaching session. Effectively the pupil addressing the class, being projected via the webcam, laptop and IWB combination, and being recorded on the laptop for future revision, in the context of the previously displayed list of buzz words, provides the material for them to work with and on which to comment. While only one pupil can present at a time, all have a part to play in the ensuing classroom dialogue and resultant cumulative learning outcomes.

The teacher also makes use of animations to indicate scientific method, such as the process of separating solids from liquids etc. Animations usefully draw attention to the most salient processes to the questions being explored. Following use of this dynamic presentation, she states: "I want you to have these ideas in mind as we work. Last week we..... " (as she points to photograph from last week). Unlike the animation this is a still with the actual limits of photography (e.g. unlike the animation where arrows point in direction of evaporation for example). However, the verbal description, combined with the photograph, combined with the recency of the experience of the animation all inter-relate coherently. Again she makes reference to "ideas in mind" - she appreciates the cognitive work in making connections, and does not leave it to happen (or not) by itself. Perhaps too it is the making use of multiple repetitions across semiotic domains, in different combinations, that conspire to make

the very repetitions constantly engaging rather than boring, and challenging rather than patronizing?

Spontaneous responsiveness to situations as they arise: orchestration and managing the unexpected

The IWB allows the teacher to manipulate the flow of events, so that the teacher can be improvisational and spontaneous, when situations arise, without sacrificing the overall flow of the lesson. Our data demonstrate the importance of the teacher's orchestration of resources, with language, managing and drawing salience to key aspects of the content, resources and actions. Within this we see the teacher's use of external representations in "enhanc(ing) the educational benefits of collaborative conversation" (Sawyer & Berson, 2004, p.390). One of many educational challenges teachers face in orchestrating discussion is how to develop pupil reflection and recap previously worked material without channelling pupil input/contribution. This can be seen when addressing what happens when the resources are taken up in talk.

An instance of orchestrating resources and managing the unexpected occurred in a Year 3 literacy lesson (age 7-8) on writing instructional texts, based on the activity of making pancakes. Displayed on the IWB was a pre-structured block-reveal activity of the various stages involved in making pancakes, which the pupils were asked to suggest before they were revealed. One pupil's reflection on the material on the IWB was a stage in the process which the teacher, Paul, had not listed on his lesson slide (putting oil in the pan). Paul acknowledged this as a valid contribution in the discussion around the IWB resource, but did not take advantage of the IWB's mutability to update his resource. This could have been for a variety of reasons, such as time constraints at that particular point in the lesson. Indeed at a later point in the lesson using a different IWB slide as a template Paul did update his resource in direct

response to a pupil's suggestion of information that was missing from the pre-planned display.

The inter-relationship between analytic foci: An example

Up until this point we have considered each of our analytic foci in turn, but it was evident that these do not occur in isolation, rather they inter-relate and co-occur. We will further our discussion of the teacher's spontaneous responsiveness at this point to highlight the inter-relationships between our analytic foci. Such inter-relationships were apparent in a Year 5 history lesson on Aztec foods. The teacher had brought in a range of contemporary Mexican foodstuffs specifically to resource a discussion designed to 'bridge' the children's understanding from a consideration of familiar foods to those the Aztecs consumed. However, she had to adapt this orienting discussion and her lesson plan to accommodate the pupils fascination with, and the questions they raised, as to whether or not the Aztecs ate dogs.

The pupils' curiosity about the possibility that the Aztecs ate their dogs impacted on the discussion of planned content throughout the lesson. When asked at the start of the lesson to think of three things they wanted to find out, to be written on the IWB, whether or not the Aztecs ate dogs was the focus of one of these aspects (lesson 2, 05.00). It was also a pupil's response to Jane's question of what Aztecs ate for protein (15.20). As another pupil followed this with a related question, the teacher acknowledged that they did eat a certain type of dog and elaborated further. The topic re-entered the discussion when pupils shared their descriptions of an Aztec kitchen and some pupils listed dog when working on a task toward the end of the lesson to describe Aztec food. Finally the question arose again in revisiting the IWB slide to address whether the class have answered the three questions posed at the start of the lesson.

While Jane had probably not anticipated this intense focus on dogs as a food item within the Aztec diet, she was able to respond to the pupils' queries and interests in line with the more general learning aim of Aztec food, and also in the context of the pupils' understanding of modern and Western food and eating habits. The points that the pupils added to this IWB slide, which served as an improvable object, however, emerged from the individual pupils' contributions to the subsequent group and whole class discussions. It acted as an enduring reminder of the lesson topic and aims, available for re-annotation and revisiting. Thus we see, to return to our first analytic focus, that connections were built backwards and forwards as part of the emergent trajectory of meaning making.

Through the activity of engaging with pre-existing materials and authoring their own additions, the pupils transformed the resource, guided by their teacher (our second analytic focus). The IWB slide of pupils' questions created by the pupils and teacher at the start of the lesson had acted as an enduring reminder of the lesson aims, propelling movements from the known to the new and from everyday to the academic, our third analytic focus. Accompanied by the Aztec music, this resource was available for revisiting throughout the lessons, in structuring the discussion and pupils' understanding and questions on Aztec food

This illustrates how the IWB in the history and literacy classes was interpreted as offering a focus for the activity, being orchestrated in different ways to match the varying learning needs throughout the lessons. Part of the spontaneous responsiveness is about managing the unexpected questions and comments the children themselves come with. Activities can emerge from interactional contexts, not directly from the lesson plan or technology/technological resources. In this way teaching is far more than following the curriculum, it is a creative act of transformation.

Conclusion

We have looked at aspects of what we term processes of orchestration of a rich blend of multiple resources by the teachers skilled in use of the IWB in our study. Kress (2007) emphasises the importance of learning environments evolving to utilise the increasingly multimodal and multimedia world in which today's students live. In the deployment of diverse semiotic resources – which is made relatively easy by the IWB in comparison with its predecessors – the teacher is enabled to orchestrate resources, setting mood and tone, in sustaining engagement and attention and foreshadowing development at various levels. Thus use of the IWB can support such connection or association building in the trajectory of learning and cumulation over time. As Gee (2003. p. 73) writes, "It is the connections or associations that people make among their experiences that are crucial to learning, thinking and problem solving." Resources can be aligned to assist correspondences in terms of managing the micro transitions in the classroom, as well as bigger transitions that manage the learning across lessons. We have shown how this is achieved through orchestration of many different modalities in multimodal resources. Orchestration is a metaphor that captures the teachers' pursuit of overall goals, weaving together of themes and sub-themes, while allowing some flexibility of responsiveness in the dialogue with students. Orchestrating is not just about putting the resources in play, it is also about acknowledging and making useful pupils' contributions, as significant evidencing of a process. It is useful too as an analytic lens through which to observe and interpret the interplay of instructors' intentions realised through subtle interweaving of guided activities.

The metaphor of trajectory of meaning making for us does not therefore imply a wholly narrow and unidirectional process, as the effective construction of mutual understandings making use of multiple representations and interactions involves revisiting ideas and harnessing students' own contributions and exploring them. Therefore, with this study we offer support for the suggestion by Sawyer (2004) that effective teaching may be captured by the notion of "disciplined improvisational performance" whereby the teacher responds flexibly to classroom situations within the restrictions of time and a set curriculum. Our work suggests that the affordances of an IWB in the hands of a teacher skilled in the pursuit of educational dialogues may be of considerable use in this orchestration, and thus that coherent connection building may be successfully pursued.

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