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Using the interactive whiteboard to resource continuity and support multimodal teaching in a primary science classroom

Abstract

All communication is inherently multimodal, and understandings of science need to be multidimensional. The interactive whiteboard offers a range of potential benefits to the primary science classroom in terms of relative ease of integration of a number of presentational and ICT functions, which taken together offer new opportunities for fostering multifaceted pedagogic strategies. In this case study we examine in detail how a teacher pursues two themes across four science lessons. We examine how the teacher creates continuity in her students' learning experiences through taking up some of the affordances of the IWB in order to represent scientific phenomena and engage children in activities to consolidate their understandings. Support is offered for the notion that while pedagogic goals and strategies must determine the selection of tools, rather than the 'tail wagging the dog' as in technology-focussed hyperbole, planned use of the IWB, conceptualised as a "heterogeneous mediational tool kit" (Wertsch, 1991), can be effectively integrated into teaching practice.

Keywords

Interactive whiteboard; multimedia; mediated; primary; case study; qualitative

Introduction

This paper presents a case study of how the interactive whiteboard (IWB) is harnessed to support the teaching of primary science. Learning science is not just a matter of accumulating scientific facts. Instead, it is a gradual process by which teachers introduce students to new scientific perspectives, helping them to develop new ways of viewing the world and new ways of using language to make sense of this experience (Barnes, 1992; Mercer, 2005). Multimodal representations are particularly important in the teaching of science since the ability to move flexibly between various representations of scientific content can support the development of students' understanding of scientific phenomena (Kozma, 2003). The teacher's role is crucial in helping students to integrate new information and representations within a wider scientific frame (Mortimer & Scott, 2003).

The IWB is a "teacher-centred pedagogy….[which] together with related resources, allows the user to prepare material in advance or construct it in front of a class, quickly retrieve it for display to the whole class when required, and manipulate items directly on this display in a way that corresponds to what can be achieved with an individual PC." (Kennewell, Tanner, Jones & Beauchamp, 2007). IWBs, which can thus foster multifaceted pedagogic strategies, have been rapidly introduced into all primary schools under UK Government initiatives, thus there has been increasing research interest in how they influence established pedagogic practices, communicative processes and educational goals. Early hyperbole emphasised the perceived qualities of new technologies, as epitomised in the enthusiasm of the UK government minister most associated with their introduction into schools: "Every school of the future will have an interactive whiteboard in every classroom, technology has already revolutionised learning" (Charles Clarke, quoted in Arnott, 2004). Subsequent evaluations of the introduction of the IWB (see especially Moss et. al, 2007) have been broadly supported by a body of research that has for the most part concurred with a re-emphasis on pedagogic strategies and skills, and the extent to which these may be assisted by the new tools (see e.g. Kennewell, 2004; Higgins et al., 2005; Smith et al., 2005; and a recent special issue of *Learning Media and Technology* vol. 32, issue 3) In relation to this, the work reported on here investigates how the interactive whiteboard resources the teaching of science in the primary classroom in a specific case study.

We examine the use of the IWB from a sociocultural perspective, taking Wertsch's notion (1991) of the 'heterogeneous mediational tool kit' as a frame for this study (see also Mercer et al., forthcoming). It appears to us that this term, coined of course without reference to the IWB, captures the broad multi-functionality of a major tool, such as the IWB, together with the vast potentiality of ways in which it can be drawn upon in the course of classroom activities. In a sociocultural perspective our emphasis is on the study of tools in terms of how they are used in specific sites of activities of learning and teaching. As Wertsch comments, 'only by being part of action do mediational means come into being and play their role. They have no magical power in and of themselves.' (Wertsch, 1991, p. 119).

In this case study we examine in detail how a teacher pursues two themes across four science lessons. We examine how the teacher creates continuity in her students' learning experiences through taking up some of the affordances of the IWB in order to represent scientific phenomena and engage children in activities to consolidate their understandings

Method

Data presented in this paper are drawn from a wider project of observations and interviews from five teachers working within urban primary schools in the South of England. These schools joined the project through shared interest in exploring the IWB with the academic team and a level of expertise with the IWB that we could characterise as at least level 3 in the typology proposed by Somekh et al., (2007, p. 66) and for most probably levels 4/5.

We have focussed on Key Stage two classes (children 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. These and several additional teachers (also interested in the potentiality of IWBs) were interviewed to discuss their use of IWBs within their classroom-based teaching and learning practices. For the purpose of this paper we present a case study of detailed analysis from a series of teaching-learning episodes that span four sequential year five (age 10-11 years) science lessons on the topic of evaporation. The lessons were team taught by two teachers, one of whom we shall call Mrs Patel, who in addition to working as a teacher in the school, was an IWB advisor for her Local Authority. The other teacher (Miss Booth) was the regular class teacher.

The focus of our investigation is how the IWB in combination with other resources at the teacher's disposal are used to create continuity between ideas and events across time, in a meaning-making trajectory (Baldry & Thibault, 2006). Initial stages of 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. This first stage of analytic work revealed that the pursuit of goals was not linear, ie. one lesson objective approached, finished off and then another started but rather that complex patterns of joint meaning making began to emerge as multiple pedagogic goals were pursued and developed across time. The pursuit of these goals, therefore, is visible in waves, sometimes very explicitly evident in activities, at times submerged and then emerging later on. We term, then, the pursuit of a goal, as clearly present in activities, a 'theme'. Each of the periods when a theme or active pursuit of a goal is evident, we term an 'episode'. An episode may demonstrate the theme to be identifiably present whether explicitly in verbal interactions or otherwise indicated through all meaning making modalities i.e. use of artefacts, non-verbal representations and so on (Baldry & Thibault, 2006, p. 12). Our analysis of each theme as presented here is focussed on illustrating ways in which the IWB functioned to enhance the multimodal resources of the science classroom and how the IWB is being used to support the development of scientific understanding.

In the following section we will present analysis of specific episodes from two themes that we term 'understanding evaporation' and 'understanding particle activity' which have been selected to identify key, interesting multimodal strategies using the IWB and other representations in the classroom. These are not intended to be representative of the totality of lessons observed, but are rather explored as particularly fruitful in investigating the research questions presented above. The reasons for this selection are:

- The themes were integral and important parts of the teachers' overall aims for the lesson.
- A blend of multimodal resources were evident;
- From evidence of gaze, verbal interaction and activities, the students were clearly particularly engaged and 'on task'.

Analysis

Theme 1: Understanding evaporation

The first theme identified is linked to the aim of enabling the pupils to understand the phenomenon of evaporation. As you will see, the first episode considered shows an engaging use of video, which features the 'voice' of the teacher heard through two different media. The second episode illustrates the way in which the teacher displayed stills from the initial video, for pedagogic effect; the third episode is a subtle reworking of this representation, fit for the purpose of creating bridges to scientific understandings. The fourth episode shows how these stills help to create continuity over time and resource a trajectory of joint meaning making. We conclude with a brief analytic summary relating to this theme.

Episode 1.1: 'Going, going, gone' video: Engagement at lesson start (lesson 1, 2:56 – 3:30)

The first episode is taken from the start of the first lesson. Before posing questions for discussion the teacher opens a video file of herself on the IWB in her kitchen at home. The video shows her putting water into a hot frying pan, to demonstrate how the water evaporates. This is presented in the form of a 'magic trick'.

Teacher (in classroom)	So I am going to start off our science lesson and we will kick it off with a magic trick. OK so I want everyone to be looking really carefully so here we go... There we go. OK, right watching really carefully…	*Teacher uncovers clip on IWB* *'Going Going Gone!!' and video screen displayed on IWB*
Teacher (on video)	Hey, this is Mrs Patel. I'm standing in my kitchen and I'm going to do a magic trick. Are you ready? (*pause*)	*Teacher in classroom moves to side of IWB out of the way*
Pupils	Yes	
Teacher (on video)	I said are you ready?	*Holds hand to ear in listening gesture*
Pupils	Yes! (*louder*)	
Teacher (on video)	You see I've got an ordinary frying pan here and an ordinary glass of water. I'm going to take a bit of the water, and I'm going to put it in the frying pan. Watch carefully	*Holds up pan in left hand and runs right hand round it, lowers pan but keeps left hand on it* *Holds up glass in right hand and puts back on side* *Takes spoonful of water, and moves above pan* *Drops water into pan, which*

	Now you see it… (*pause*) Now you don't	*sizzles* *Holds up pan on its side, and no water runs out*
Pupil	Whoa!	
Teacher (on video)	Tada!	*Looks back at camera, keeps holding pan in left hand, and raises right hand to 'show off' her display*
Pupil	That is a magic trick! Wicked!	*Pupils clap,* *teacher closes programme*

This extract shows immediately how the teacher is incorporating interactivity into her teaching strategy although in material terms the functions of the IWB that are used are (merely) the presentational ones. At the onset of the clip the teacher on the video claims that she is 'going to do a magic trick', employing a playful call and response technique, with planned pauses and questions addressed to the putative audience. The style of the magic trick is supported and sustained by devices such as the use of 'going, going, gone' as the title for the video, which 'disappears' as the video begins to play, and the phrase, 'now you see it, now you don't', as the water in the frying pan disappears/evaporates. The 'magic trick' has been presented in such a form as to elicit immediate dialogue with the persona of the teacher that is presented on screen as the actual teacher stands aside. She has used a presentational technology of the IWB in way that immediately gives support to the suggestions by Kennewell et al., 2007, p.4

and Somekh et. al., 2007, p. 64 that to consider 'interactivity' as a property of IWBs when they are being used in their so-called 'interactive' functions (of annotation etc.) may be a misleading over-simplification in either direction. That is, interactivity should more validly be considered in relation to what is happening in a classroom at any given time rather than as an assumed property of a technology. In this case, Mrs Patel's prepared video presentation, which she later described as being easier to achieve with the IWB than earlier classroom technologies, clearly acted as an engaging and accessible entry point for the pupils into the topics of 'evaporation' and 'changing states'

Episode 1.2: Image, talk, text and gesture: Magic or science? (lesson 1, 03.37-09.25)

The 'going, going, gone' video is referred to throughout the lessons, framing the discourse and creating continuity as key points of it are re-presented in the form of a sequence of three captured still images that Mrs Patel captured from her video and incorporated onto screens with texts. Presenting such visual resources on the IWB was cited by this teacher in her interview as an advantage, in that it supports her in bringing 'reality back into the classroom'. The first instance of this re-presentation can be seen in Episode 1.2 which occurs when, having just played the video, the teacher introduces the images of: (1) the hot frying pan with no water in it; (2) water in the hot frying pan 'bubbling' and (3) the hot frying pan following the evaporation of the water. This sequence of images is re-presented a further three times at strategic points over the current and third lesson in the sequence, but at this point unlike the others, the images are free of any descriptive text. These images act as a recap device, ie.: 'a brief review of things that happened earlier in the previous joint experience of the class. Usually teachers do this to set the scene for the current activity.' (Mercer, 2000 p. 52). Mrs Patel, synchronising gestures and talk, uses the images to re-describe the chain of events she wants the children to consider . Underneath the images are some questions to direct the pupils to consider what 'really happened' in the video they have just seen. By following the recap images with questions posed in this way, she casts doubt on the plausibility of the magical explanation, encouraging the pupils to think in a more scientific manner.

At this point, the teacher constructs links between the video and the context of the science classroom. She emphasises that she had used 'an ordinary frying pan',clearly an everyday context, yet endeavours to elicit a more scientific term than 'vanished' from the class. When one student suggests 'evaporated' she writes onto the slide, reinforcing its significance within the lesson context [see Figure 1]. She has taken advantage of the capacity of the IWB for annotations at a particularly key point , instantiating the teacher's role in introducing concepts, guiding the flow of discourse, and persuading pupils toward the adoption of a scientific perspective (Leach & Scott, 2003).

Insert Figure 1 here

This also serves to link into the next IWB slide (not shown here) presenting a definition of evaporation with the key terms (evaporation, water vapour, changed) being highlighted in red, relative to the blue main body text. The colour contrast is used to cue salience within the current lesson frame. This definition is placed above the same image stills from the 'going, going, gone' video, although in this slide each of the three images has been aligned with a brief scientific explanation of what is occurring at the captured moments, providing correspondence between the images and the definition at the top of the slide. This re-worked multimodal presentation provides linkages between the images and theme of evaporation, and between the everyday understanding and scientific explanation, which the teacher reinforces by her use of gesture as she narrates the screen. At one point she spots a minor error in her prepared slide and acts immediately to correct it, modelling a willingness to review previous work. As the teacher moves along the sequence of images, she offers a commentary on the pictorial depiction, describing the process of evaporation, incorporating and contextualising the responses pupils gave to the prompt questions in the previous slide.

Episode 1.3: Recapping video stills: Recapping pupil understanding (lesson 1, 37.55-41.30)

At a later point (lesson 1, 37.55) in this lesson the same images are re-introduced (see Figure 2). Again they have text labels providing links between explanation and image, although this time they serve to recap pupils' understanding of evaporation. This is a re-working of the still images and associated descriptions where the label for the middle picture has been reduced from 'water bubbling and evaporating' to 'water bubbling' – the key scientific term has been removed so that there is an opportunity for the pupils to reinstate it in the explanations they offer for what is happening in the portrayed images.

[insert figure 2 here]

This scheduled reappearance of the images supports pupils in understanding that there is a correspondence between what happened in the 'going, going, gone' example and what happens when water boils in general. The appearance of this slide at the point in the team-taught lesson at which the two teachers 'swap' and Miss Booth takes the lead, also helps to ease this transition as well as resourcing continuity between the specific and general points being emphasised. As in the previous episode the images are accompanied by questions placed underneath them for the pupils to address in terms of water boiling. Certain words in the questions are highlighted, again orienting pupils toward the formulation of questions within the scientific nature of enquiry. The questioning serves to resource the formation of generalisation and equivalence of the scientific phenomenon to which the teacher wants them to attend; in interview Mrs Patel made mention of the way in which she feels that modelling the activity and line of thinking for other pupils may be especially supportive for EAL and SEN children.

Miss Booth then introduces these questions as a feeder activity into the task which closes the lesson, of watching what happens when a transparent-sided kettle boils. It can be noticed in passing that since it does not have the same health and safety implications, the kettle is actually present in the classroom. Yet videoed and captured stills from the kettle are also integrated into subsequent lessons, further extending the repertoire of images that, however 'everyday' in origin, are made engaging and the subject of scientific enquiry for the students. Meanwhile, the questions and recap images of Figure 2 are used to facilitate the multidirectional transition between the two tangible examples of the frying pan and kettle and the general scientific explanation of evaporation, in encouraging pupils to predict what will happen when the kettle boils. In building on the specific to general focus and description to explanation strategies at the start of the episode, the teacher makes a move from the scientific to the everyday, from general to specific, and from explanation to generalisation. This provides the kind of discursive support for learning science advocated by Mortimer & Scott (2003) and other science educators.

Episode 1.4: Recapping video stills: Extending concepts learned (lesson 3, 00.55-04.15)

This episode exemplifies the trajectory of meaning making activity over time, as the evaporation theme is picked up in the third lesson and explored further in the fourth. Learning objectives are always presented on the IWB and discussed at the beginning of the lesson. Objectives for lessons three and four include knowledge objectives concerning how different conditions affect rates of evaporation (1), and the concepts of fair testing (2), as well as a practical skill objective of planning their own fair test to investigate rates of evaporation (3). The learning objectives build on the pupils' understanding of the concepts of evaporation and the categories of solid, liquid and gas: this exemplifies moving backwards and planning forwards in terms of material covered and to be introduced. This conceptual understanding is extended to a more detailed level in terms of rates of evaporation.

As an introduction to rates of evaporation, Mrs Patel commences the final presentation of images from the 'going, going, gone' video, with the same text labels as in their last presentation. The teacher reviews the process quickly, combining gesture and talk to cue key points as she moves through the images, building the resource into the context of the current lesson to re-immerse pupils in the topic introduced in the previous week. She evokes the language from the original context of presentation in referring to the ‘cool magic trick’ that she had performed, to facilitate orientation to the class’s shared experience. The second image is labelled ‘water bubbling’ rather than ‘water bubbling and evaporating’ as it had been the first time it was used. . This may reflect the purpose of the images’ presence at this point to elicit a recap of the pupils’ understanding of the scientific concepts and terminology.

The bottom half of the screen aligns the images with scientific discourse, with the prompt question ‘what is evaporation?’, and key terms arranged underneath. With the key descriptor memory prompts available to the pupils, Mrs Patel attends to the theme of the past two lessons in inviting pupils to reconstruct a definition of evaporation. Pupils offer lengthy answers which make use of all the terms presented, as well as others and refer to previous explanations. One such pupil is invited to come to the IWB to re-arrange the terms to create a diagrammatic representation of the process of evaporation to accompany his narrative (see figure 3). The physical adjustments of the labels evidently correspond to his cognitive understandings of the sequencing of processes. Also, just as Mrs Patel had done in previous uses of the images on the IWB, the pupil occasionally points to them when they are made salient within his explanation of evaporation; meanwhile the other pupils appear particularly attentive. It might indeed have been still more interesting if he had been encouraged to use the pen facility to add in other key terms such as 'steam'. However, it does seem to us that an overarching aim of this episode has been to create 'mental interactivity' in the sense suggested by Somekh et al. (2007, p. 64). As those commentators of such an occasion when one pupil was interacting with data on the board in front of others remarked, paradoxically the effect of such an engagement may be temporarily to slow down the pace. Nevertheless we would agree that rather than over-valuing maintenance of pace, it is worth considering what value overall is gained. The amount of preparation, and place of this activity within the overall trajectory of meaning making in theme one has been considerable. The teacher's provision of images and terms for the pupils to use in doing this resources the adoption of elements of scientific discourse as building blocks toward an understanding of the phenomenon and process of evaporation.

Analytic summary on theme one

Having been initially used as a multimodal, engaging starter or 'anchor' (Schwartz, Lin, Brophy, & Bransford, 1999), the video images are presented and re-presented as captured still images on the IWB at key points in the first and third lessons. In combination with brief textual summaries and scientific labels, these are used to constitute the initial 'bridging representation' (Savinainen, Scott, & Viiri, 2004) from which the children are encouraged to question the mystical, magical explanation of what they first saw, and to consider the scientific explanation. Key science terms within definitions are highlighted in a distinct red to carry 'high sensory modality' (Kress & van Leeuwen, 1996, p. 171). Stills from the video are repeatedly re-versioned, re-presented and used as a reference point across the lessons - providing an example to be re-visited, re-worked and re-described. These representations are also used in combination with, and to complement, other representational forms and resources such that the 'different semiotic modalities co-contextualise each other' (Baldry & Thibault, 2006, p. 18). The re-use of the same stills in these four lessons serves three distinct but related purposes: to create continuity across lessons; to consolidate shared experience and create common understanding; and to bridge between everyday and scientific explanations of evaporation.

Theme 2: Understanding particle activity

Theme one is focused on observable phenomena, and provides the springboard within the unfolding trajectory of meaning making to move onto the abstract, scientific concepts introduced in theme two. The second theme identified is linked to the aim of enabling the pupils to understand the phenomenon of particle activity in solids, liquids and gases. The IWB, as a multimedia presentational device, is harnessed with other resources to support the introduction and exploration of key scientific concepts and discourse. It helps to resource a cumulative dynamic, facilitating the development of the scientific story as well as building coherence between and affording generalisation to other everyday occurrences: in her own words, the teacher often used the IWB to 'set up an activity to reinforce something or consolidate something' (Mrs Patel). The teachers are then able to build on these activities and representations, as they introduce the scientific concepts of solids, liquids and gases in more abstract terms of particle attributes and activity.

In the first episode discussed, the teacher makes a staged introduction to the IWB screen that constitutes the key resource for this theme. In theme one, the screens were all connected with the initial video, while displaying some variation. In contrast, this theme is worked through by means of promoting understanding of the relatively complex material presented on a single screen. The second episode is an example of how the teacher invites the pupils to enact a kinaesthetic response to the non-visible phenomena of particle activity. The teacher's task is then to provide a conceptual bridge to understanding the differences of particle activity relating to changing states, as exemplified in episode 3. In episode 4 the opportunity for a further kinaesthetic response is presented in order to consolidate understanding.

Episode 2.1: Re-capping particle attributes: Introducing solid particle activity (lesson 1, 22.45-23.45)

Activities within this second theme of episodes follow a whole class task on categorising images of everyday items as solids, liquids and gases into a table on the IWB. In doing this Mrs Patel has oriented the pupils to the attributes specific to the three different states, via a knowledge entry point the pupils already possess on 'real life' examples of solids, liquids and gases. In contrast to theme one, this theme has one IWB screen as its stable feature.

This episode of teacher talk is fairly long and uninterrupted by the pupils. Initially Mrs Patel quickly recaps the visible properties of different states of matter, before moving into what these visible properties mean in terms of invisible particle activity for each of the different states. Here she is using the task they have just done in categorising items in terms of their state, to introduce the 'second reality' (Mortimer & Wertsch, 2003) of scientific language in dealing with abstract concepts and attributes, in this case particle activity, which only become meaningful within the context of scientific discourse. This talk from the teacher is accompanied by text at the top of the IWB screen, underscoring what she is saying to the class. Again as in theme one, red font directs attention to key terms within the main body of text displayed in blue font.

Below this text are three large blue blocks, which the pupils know are hiding some information to be revealed. The teacher has prepared information underneath these blocks which she can remove to control the pace of movement through the concepts, hereby employing the 'block-reveal' technique commonly used in IWB presentation. In the extract presented below, the teacher has summarised the ground they have covered on properties of solids, liquids and gases, introducing the new notion of these attributes in terms of particle activity. She is just about to remove the first block, referring to the animation and text this reveals of particle activity in a solid.

Teacher	And particles in different materials, in solids, liquids and gases, behave in different ways. I am going to reveal the first one. Is it behaving this time? There we are, OK. Particles in a solid are packed really, really tightly together and they just vibrate or jiggle about and they don't move from place to place. That's why solids don't change their, most solids don't change their shape.	*Removes first block* *Points to text just revealed* *Points to moving image of particles in a solid*

Under each of the three blocks is a moving image with adjacent descriptive text depicting either solid, liquid or gas particle activity. In using this 'block-reveal' technique Mrs Patel can pace her presentation and focus attention to key features as she deems necessary. She identifies points of continuity (the particles have some movement) and difference (the particles move at different speeds) between the three states and representations. Her text on the IWB and accompanying commentary aim to bridge the everyday to scientific language, such as in the phrase on the IWB, ‘they vibrate (jiggle) but do not move from place to place’, to provide a gloss from everyday language for the new term ‘vibrate’. The teacher makes pointing gestures as she reads the text next to the images, to alert pupils to the correspondence between the text and animation, and also closes the loop from particle attributes to activity back to attributes in her statement, ‘that’s why solids don’t change their, most solids don’t change their shape’.

Episode 2.2: ‘Pretend to be a solid’: Pupil enactment (lesson 1, 23.45-24.30)

At the end of this, and after revealing and discussing each of the other two states of particle activity, the teacher invites a group of pupils to come to the front of the class to ‘act out’ the particle activity corresponding to the one portrayed in the animation. The still below [figure 3] shows the pupils asked to ‘pretend to be a solid’. This is a means by which the pupils engage kinaesthetically with the meaning of this scientific phenomenon that is of course only accessible through indirect analogies rather than direct perception.

[insert figure 3 here]

Episode 2.3: Revealing liquids: Predict and reveal (lesson 1, 24.30-25.35)

Having facilitated the pupils' explorations of the notion of a solid through a dynamic two-dimensional image, class discussion and pupil role play, the teacher gives a brief summary of particle activity in solids. She then invites pupils to suggest what they think particle activity in a liquid might look like. Whilst Mrs Patel did not do this before revealing the block covering the information on solids, she is able to collect pupils' contributions at this point to see if the pupils can form their own correspondence between what they know about attributes of solids, liquids and gases and what they can see on the IWB regarding particle activity in a solid, to make the transition and generalise to predict the abstract, scientific configuration of particles within a liquid.

After pupils have offered their ideas, rather than providing an immediate, explicit evaluation, the teacher reveals the image and text for particle activity in a liquid, hidden under the second block. As happened with the portrayal of a solid, Mrs Patel reads the descriptive text, pointing to create continuity between the description and image. Now that more information is presented however, she keeps the particle activity of a solid firmly within the discourse, highlighting comparison and contrast by pointing between the animations of solid and liquid particle activity.

Episode 2.4: Acting out liquid particle activity: Putting words and pictures into action (lesson 1, 25.35-26.06)

Following this, another group of pupils is invited to 'act out' the particle activity of a liquid. As this occurs for each of the three states of matter, the teacher attempts to form continuity and coherence between the categorising task of everyday examples of solids, liquids and gases, through the animations of these objects as abstract particles with different levels of movement and space, and back to a concrete enactment of this movement and space in the pupils' dramatisations.

Analytic summary of theme two

Theme two is rich in respect of the teacher's use of multiple representations, while being centrally focussed on presentation of a single screen. The teacher utilises texts and animations on the IWB, takes up pupils' suggestions in her discussion and also invites the pupils to embody particle activity in role play for the three different states of matter. The combination and alignment of the transitory physical movement pupils experience or watch as some of them act out particle activity, together with the continuous display of simulated movement and adjacent scientific text of particle activity on the IWB display afford linkages between these elements. This offers a way of bridging between the experiential episodes and abstract scientific theme of particle activity.

As with the re-use of the 'going, going, gone' images through the lessons, the particle activity theme also shifts from the everyday domain with tangible, visible examples (the categorising task), to the abstract, theoretical, scientific explanations. These are built up in this theme through use of the information presented on the IWB, elaborations resourced by the teacher’s descriptions and gestures, and the acting out of phenomena by the pupils. Throughout the theme the latter two of these resources (teacher elaborations and pupils acting out) are largely transitory representations, whereas the IWB forms a cumulative backdrop as an updating source of reference and attention for the development of ideas and correspondence between particle attributes (‘most solids don’t change their shape’) and activity (‘particles in a solid are packed really, really tightly together’).

At the end of the theme, information on the three levels of particle activity now available pictorially depicts a transition from solid to gas, and shows the continuation of space and movement as key points in defining solids, liquids and gases. Having viewed, discussed and acted out particle activity in the three different states of matter, the teacher leads the class toward the next part of the lesson on what ‘changing state’ might mean. At this point she orchestrated the development of a new diagram to illustrate the concept of 'changing states'; although she was the only person wielding the pen, she took up students' suggestions as to its compilation.

The IWB and incorporation of the block-reveal strategy offered the initial structure for the unfolding of the theme, whilst also allowing material to be revealed in line with the pace of the lesson. The flexibility afforded to control timing in this way is valuable in easing movement through the representations and text, and supports cumulative knowledge building, integrating previous and new information, which can be a difficult and complex educational challenge (Alexander, 2000).

Conclusions

The evidence from the case study suggests that the IWB may be a useful heterogeneous toolkit in facilitating interactions with multiple modes of representation. It is not that access to these modes was previously impossible for teachers, but rather that this technology makes it so easy and convenient for the teachers to deploy them as rapidly as wanted to facilitate their aims. So although all teachers are striving for continuity in lessons and may be willing to use a wide range of resources, the IWB facilitates the accomplishment of this. It could be argued that teachers can use a frying pan, video projection, create new large-scale diagrams and save them and so forth, but to use complex combinations of artefacts can be time-consuming, impractical in certain circumstances and have impact on the pace of the lesson. Of course, recognition of the relative ease of use of multiple resources facilitated by the IWB must not detract from the need for preparation that is necessary to enable these effective deployments; the initial episode that we have identified as so fundamental to the flow of these lessons demanded both forethought and prior activity by the teacher. Nor should it eliminate physical demonstrations or practical experiments; indeed this sequence ended in planning forthcoming experiments on evaporation. Our analysis has tried to capture the complexity of the multiple semiotic modes in play as a teacher pursues a pedagogic goal. In the subsequent interview Mrs Patel volunteered: ‘Because that’s what I think the whiteboard’s done more than anything else is scaffolding the learning, really helping them to move, to that next step… whether it’s visually or with sound.’

We have offered support for the notion that 'interactivity' need not be reduced to those occasions when the so-called 'interactive' aspects of the IWB as opposed to the presentational functions, are being employed. However, it is beyond the scope of this paper to further consider the breadth of potential for interactivity across individual, group and whole class communications; we have been unable to indicate the salience of the relationship of the considerable periods of time across the lessons when the IWB was not in use at all. These balances would seem intrinsic overall to the degree of success of the lessons; we would agree with the proposal by Kennewell et al. (2007, p. 4) that 'We would expect effective teaching to incorporate a variety of levels of interactivity, as appropriate to the learning objectives.'

In conclusion then, we would make two final points. First, the heterogeneous toolkit that is the IWB makes possible what Lemke (1998) terms a 'multiplying effect': i.e. 'to capture the way in which different semiotic modalities co-contextualise each other in ways that are not predictable on the basis of the different semiotic resources seen as separate modalities' (Baldry & Thibault, 2006, p. 18). We find that the full potential of this multiplying effect is realised through fostering the development of scientific understanding within a 'meaning making trajectory [involving] the *progressive integration* over time of the semiotic resources that are encountered … A trajectory may last mere seconds or minutes or it may occur over much longer periods of time, as well as being picked up and resumed across separate occasions' (Baldry & Thibault, 2006, p. 116).

Second, the use of the IWB, or any new technology, can only be evaluated in pedagogic context. Our analysis has demonstrated that it is inadequate merely to dwell upon the different modes employed; it is necessary to appreciate and evaluate their dynamic deployment by the teacher. The teacher takes advantage of her view that her pupils are ‘a lot more engaged, they’re focussed, they love using the whiteboard’ to engage students multimodally in a series of recaps, elicitations and reformulations which create cohesion and continuity from what might otherwise be seen by students as no more than a series of disparate events. Tracing themes has enabled us to demonstrate how, over time, the teacher interweaves different modalities to construct this cohesion and continuity.

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References

Alexander, R. (2000) *Culture and pedagogy: International comparisons in primary education.* Malden, Massachusetts: Blackwell Publishers.

Arnott, S. (2004) Computers to replace blackboards. *Computing* 9th August. http://www.computing.co.uk/articles/print/2070841 Accessed 8th March 2006

Baldry, A., & Thibault, P.J. (2006) *Multimodal transcription and text analysis*. London: Equinox.

Barnes, D. (1992) The role of talk in learning. In *Thinking Voices* (ed. K. Norman), 123-128. London: Hodder & Stoughton.

Gillen, J., Kleine Staarman, J., Littleton, K., Mercer, N., & Twiner, A. (forthcoming) A "Learning Revolution"? Investigating Pedagogic Practices around Interactive Whiteboards in British Primary Classrooms. *Learning, Media and Technology.*

Higgins, S., Falzon, C.,Hall, I., Moseley, D., Smith, F., Smith, H. and Wall, K. (2005) Embedding ICT In The Literacy And Numeracy Strategies: Final Report (Newcastle, Newcastle University).

Kennewell, S. (2004) Researching the influence of interactive presentation tools on teacher pedagogy. Paper presented at BERA 2004 http://www.leeds.ac.uk/educol/documents/151717.doc

Kennewell, S., Tanner, H., Jones, S. & Beauchamp, G (in press). Analysing the use of interactive technology to implement interactive teaching *Journal of Computer Assisted Learning (Online Early Articles).* doi:10.1111/j.1365-2729.2007.00244.x

Kress, G., & van Leeuwen, T. (1996) *Reading images. The grammar of visual design*. London: Routledge.

Kozma, R. (2003) The material features of multiple representations and their cognitive and social affordances for science understanding. *Learning and Instruction*. 13, 205-226.

Leach, J., & Scott, P. (2003) Individual and sociocultural views of learning in science education. *Science & Education*. 12, 91-113.

Lemke, J.L. (1998) Multiplying meaning: Visual and verbal semiotics in scientific text. In *Reading Science* (ed. J.R. Martin & R. Veel), 87-113. London: Routledge.

Mercer, N. (2005) Sociocultural discourse analysis: analysing classroom talk as a social mode of thinking. *Journal of Applied Linguistics*. 1,2, 137-168.

Mercer, N. (2000) *Words and minds: How we use language to think together.* London: Routledge.

Mercer, N. Gillen, J., Kleine Staarman, J., Littleton, K. and Twiner, A. (forthcoming) *Interactive Whiteboards: does new technology transform teaching? In Learning* *across sites: new tools, infranstructures and p*ractices (eds S. Ludvigsen, A. Lund, I. Rasmussen & R. Säljö) Oslo: InterMedia..

Mortimer, E.F., & Scott, P.H. (2003) *Meaning making in secondary science classrooms.* Maidenhead: Open University Press.

Mortimer, E.F., & Wertsch, J.V. (2003) The architecture and dynamics of intersubjectivity in science classrooms. *Mind, Culture and Activity*. 10 (3), 230-144.

Moss, G., Jewitt, C., Levaaic, R., Armstrong, V., Cardini, A. & Castle, F. (2007) The interactive whiteboards, pedagogy and pupil performance evaluation: an evaluation of the schools whiteboard expansion (SWE) project: London Challenge. DfES Research Report RR816.

Savinainen, A., Scott, P., & Viiri, J. (2004) Using a bridging representation and social interactions to foster conceptual change: Designing and evaluating an instructional sequence for Newton's third law. *Science Education*, 89, 175-195.

Schwartz, D.L., Lin, X., Brophy, S., & Bransford, J.D. (1999) Toward the development of flexibly adaptive instructional designs. In *Instructional design theories and models: A new paradigm of instructional theory, Volume II* (ed. C.M. Reigeluth), 183-213. Mahwah, New Jersey: Lawrence Erlbaum Associates, Inc. Publishers.

Smith, H.J., Higgins, S., Wall, K., & Miller, J. (2005) Interactive whiteboards: boon or bandwagon? A critical review of the literature, *Journal of Computer Assisted Learning*. 21, 91-101.

Wertsch, J.V. (1991) Voices of the Mind: a sociocultural approach to mediated action. Hemel Hempstead: Harvester Wheatsheaf.

List of figure legends

Figure 1

Teacher annotating slide including stills from her own video

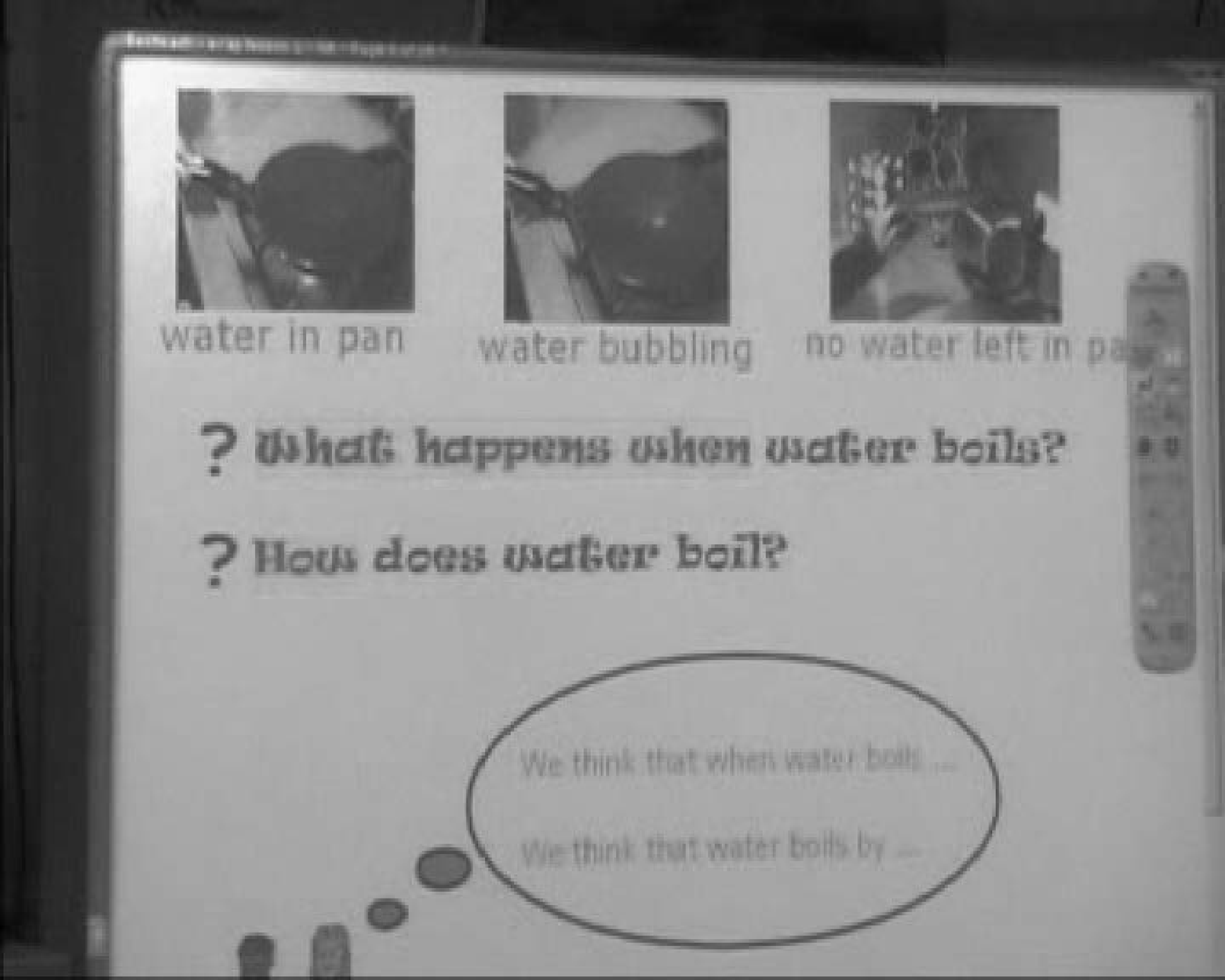
Figure 2

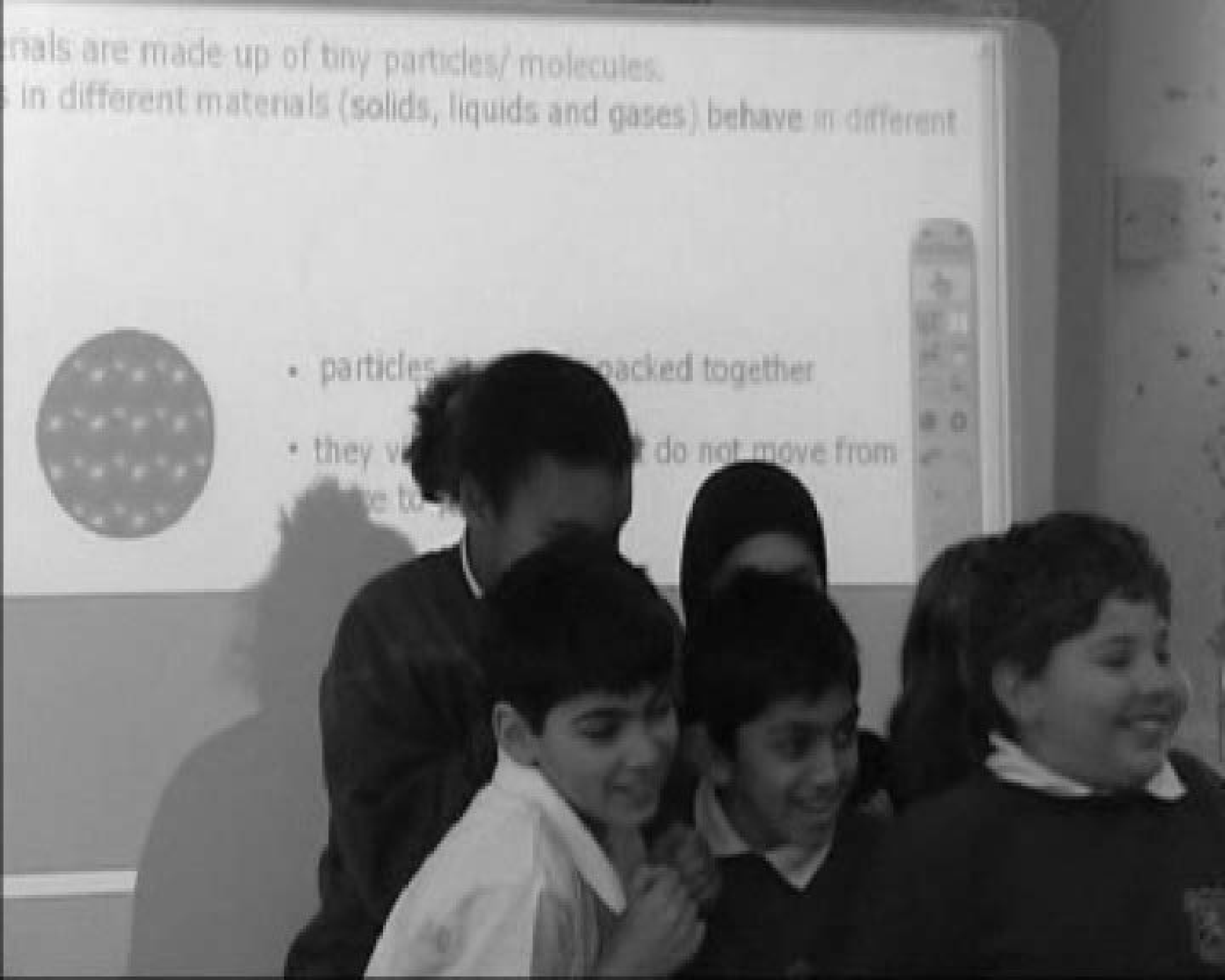
Discussion prompts

Figure 3

Pupils acting being a solid


With your talk partner, discuss these questions:
?Has the water really disappeared/ vanished?
? What has happened to it?
? Where did it go? Where in the room is it?
? How has it got there?


water in pan
water bubbling
no water left in pa
? What happens when water boils?
? How does water boil?
We think that when water boils ...
We think that water boils by ...


are made up of tiny particles/ molecules.
in different materials (solids, liquids and gases) behave in different
packed together
do not move from