
***Teacher Mediation of Subject Learning with ICT: a MultiMedia Approach***

UNIVERSITY OF CAMBRIDGE
*Faculty of Education*

# Exploring teacher mediation of subject learning with ICT: A multimedia approach

**RES-000-23-00825 T-Media Project (2005-2007)**

## End of Award Report to ESRC

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## Background

The T-MEDIA research investigated subject teaching practices incorporating use of projection technology – data projectors and interactive whiteboards (IWBs)[1]. The UK is the most prominent investor globally in IWBs, now widespread in schools. Despite their meteoric rise in popularity, assumptions about 'transforming pedagogy' were not empirically based. Government-commissioned evaluations and other recent work in the field (see reviews by Glover et al., 2005, Smith et al., 2005, and Sept. 2007 issue of *Learning, Media and Technology)* are now providing insights. Teachers and learners are enthusiastically adopting this powerful tool, ideally suited to supporting *interactive whole class teaching,* where learners test their developing understanding against corporate meaning (e.g. Jones and Tanner, 2002). Over time IWB use becomes embedded as a mediating artefact for classroom interactions (Somekh et al., forthcoming). However it is also associated with superficial collaboration, motivation and participation at the expense of uptake questioning (Higgins et al., 2005), pupil talk and reflection (Gillen et al., 2007, Smith et al., 2006, Becta, 2003, Kennewell et al., 2007).

Crook (2007) argues that introducing new technologies reconfigures existing practice but must be grounded in understanding of its structure. The effort of refocusing on new curriculum areas hourly can obstruct secondary teachers and learners from negotiating a shared object for their activity (Somekh, 2005). Pressure to maintain lesson pace means that IWB use may decrease thinking time and opportunity for pupil input, resulting in teacher-only operation (Moss et al., 2007). In our SET-IT[2] studies of IWB use in science, pupils' physical manipulation of objects was desired by teachers but constrained by systemic school and subject cultures, curricular and assessment frameworks (Hennessy et al., 2007).

Our sociocultural perspective asserts that the strength of projection technologies lies in their support for collectively evaluating pupils' ideas, and co-constructing new knowledge – 'deep' interactivity (Hargreaves et al., 2003). We have argued that the IWB provides a *dynamic and manipulable object of joint reference offering new forms of support for 'intersubjectivity'* (Hennessy et al., 2007). Intersubjectivity is a form of socially shared cognition which facilitates explicitation and exchange of ideas, and negotiation of new meanings in accordance with others' perspectives (Rogoff, 1990). T-MEDIA builds upon recent formulations emphasising dialogue (Mercer and Littleton, 2007), exploiting the distributed expertise of all students (Sutherland et al., 2004), and 'participationism' (learning through interpersonal communication and adjustment to

[1] Interactive whiteboard systems comprise a computer linked to a data projector and a large touch-sensitive board displaying the projected image; they allow direct input via finger or stylus so that objects can be easily moved around the board ('drag and drop') or transformed by teacher or students. They offer the significant advantage of one being able to annotate directly onto a projected display and to save the annotations for re-use or printing. The software can also instantly convert handwriting to more legible typed text and it allows users to hide and later reveal objects. Like the computer + data projector alone, it can be used with remote input and peripheral devices, including a visualiser or flexible camera (eg to display and annotate pupils' paper-based work or experimental results), slates or tablet PCs.

[2] *Situated Expertise in Technology-integrated Teaching: Mathematics and Science (SET-IT),* funded by ESRC (R000239823) in 2002-04.

new discourses: Sfard, 2006) . The IWB potentially contributes to creation of a fluid 'shared communication space'. Its affordances of *interactivity* and *multimodality* (Jewitt, 2006) – offering manipulation of text, colour, sound, still and moving images – provide new opportunities for learners to publicly express ideas, receive critical feedback and reformulate – both verbally and using other representations. However technology-driven pedagogy and 'pace' concerns can promote superficial exploitation (Jewitt et al., 2007). We explored how reflective practitioners might harness projection technology and particular softwares (Armstrong et al., 2005) to create space, time and status for pupil contributions, challenge thinking, offer responsive assistance – and constraints operating. We drew particularly on Mortimer and Scott's (2003) characterisation of *dialogic* interaction: teacher and pupils exploring ideas together and co-constructing understanding.

### *Collaborative theory building*

The reflexive, 'participatory' approach (Elden, 1981) taken to deconstructing classroom practice engaged researchers and teachers as "co-enquirers". It respected the teacher's 'voice' in building on interactive "co-learning" agreements (Wagner, 1997), contrasting with the power imbalance characterising most academic research (Triggs and John, 2004). Our collaborative theorising also addresses the gulf between research and development, and context-insensitivity of grand theory (Burkhardt and Schoenfeld, 2003). It was developed after working with teacher-researchers whose initially idealised 'practical theories' or perspectives on how technology supports learning (Deaney et al., 2006) evolved through interaction with beliefs about 'what works' in the setting, i.e. tacit 'craft knowledge' (Cooper and McIntyre, 1996), yet remained superficial, highlighting the need for 'rigorous and critical debate' within 'quality conversations' focused on the specifics of teaching (Wallace, 2003, p.11-12).

We drew on the idea of an 'intermediate theoretical scope' (diSessa, 1991) that is located and serves as a bridge between specific setting and grand theory, specifying conditions in which theory applies. Design-based research methodology portrays how reflection and theory building may occur at an intermediate level of analysis focusing attention on the pathways connecting learning theory and practice (Cobb et al., 2003). Here ***'intermediate theory'*** was developed through bringing together the 'scholarly' knowledge of university researchers with what we term *'applied practical theory'* – a synergy between experienced teachers' practical theories and their 'craft' knowledge.[3] This conceptualisation assumes that practical theory is situated in local, authentic pedagogical practices, related to specific pupil groups and other features of particular settings, evolving through adaptation to those settings (Ruthven et al., in press, Putnam and Borko, 2000). Engaging with each other's practices through a sustained, dialogic cycle of exchange (Ruthven, 2002) allowed us to adapt elements of sociocultural theory to fit the classroom contexts selected as its testbed.

Finally, recent work informative in designing our professional development materials illustrates

[3] In this context of projection technology use, 'craft knowledge' resonates with Mishra and Koehler's (2006) notion of 'technological pedagogical content knowledge' or TPCK: a complex, dynamic form of situated knowledge developed by teachers as they integrate new technology into their pedagogy for transforming subject knowledge into teaching. It describes how they develop specialised strategies for exploiting the range of representations, analogies and demonstrations that can help make subject matter more accessible to learners.

successful approaches based on modelling, observing, reflecting, mentoring and peer discussion (Kemeny, 2007, Miller and Glover, 2007). Working through issues and drawing on challenging external input (Sorensen et al., 2006) are key elements of the 'participationist' approach that we again apply, describing the ethos of our activities.

## Objectives

Our original aims and objectives were met in full and remain unchanged, apart from shifting away from the term 'effective' in response to referees' comments. Three are addressed under ***Methods – Participants and Data Collection:***

- To record, analyse and document exemplary cases of established teaching practices that integrate use of ICT in supporting subject teaching and learning at secondary level.
- To elicit, identify and represent the craft knowledge that guides teaching and learning in these cases.
- Using a peer interview technique, to stimulate students involved in these cases to articulate, and reflect on, their ideas about how teachers successfully mediate use of ICT and how this supports their learning; to feed these back to teachers.

The next aim is addressed in detail under ***Methods – Video Review and Data Analysis:***

- In collaboration with practitioners, to conduct within-practice and cross-case analyses aimed at characterising [effective] pedagogic strategies, activities and styles of classroom interaction involving ICT use.

The final two aims are addressed under ***Results*** and ***Outputs*** respectively:

- To draw on and extend socio-cultural learning theory so as to develop a theoretically guided model of teacher mediation of activity to support learning with technology.
- To compile and disseminate annotated audiovisual accounts providing replicable exemplars of [successful] practices.

## Methods

### *Participants and data collection*

In-depth case studies were carried out with four UK secondary teachers of English (Jackie), Mathematics (Sarah), Science (Chris) and History (Lloyd) and their mixed ability students in years 8 and 10 (aged 12-15). These experienced, reflective practitioners used technology in their everyday practice and had participated in our previous research[4]. Their three schools were all state-

[4] Two of the teachers were Heads of Department, one was a Head of Year, the fourth was Assistant Principal, Advanced Skills Teacher and lead science teacher for Cambridgeshire, specialising in IWBs. Two had participated in the *TIPS (Technology-Integrated Pedagogic Strategies)* project (2000-02), and two in the *SET-IT* project (2002-04).

funded mixed 11-16 colleges with specialist status[5], within a 25-mile radius of Cambridge. Teachers were each observed and filmed over a unit of work comprising 6 lessons (plus one familiarisation lesson[6]). The main (mobile) video camera was positioned mainly at the back of the classroom, and followed the teacher. A (fixed) second camera at the front captured students' faces.

Semi-structured teacher interviews were conducted during planning, after the third and final lessons, and after the analysis. Two pupils were trained to interview their classmates. Groups of six (randomly chosen by the teacher) were interviewed after the third and final lessons. All post-lesson interviews employed prompt cards (see Appendices 1-5). Teachers kept unstructured diaries recording their lesson planning, decision making and/or post-lesson reflections and suggested modifications.[7] Screen displays and annotations were saved and copies made of pupil work, lesson plans, handouts etc.

The mathematics teacher used a data projector, tablet PC and laptops while the others had permanent access to an IWB. The **English** lesson sequence focused on collaborative interpretation of poetry exploring the theme of anti-social behaviour. The **history** teacher exploited multiple digital resources to support collaborative analysis of evidence concerning the 'golden age of Queen Elizabeth I'. The **mathematics** teacher used several technologies, including graphing software, to develop understanding of intercept and gradient relating to straight line graphs. The **science** sequence focused on understanding the photosynthesis process, plant cell and leaf structure.

BERA ethical guidelines (Appendix 6) were followed throughout the study, particularly with respect to "Responsibility to participants". Care was taken to make the research aims and methods explicit so that informed consent was obtained from all participants. Pupils were interviewed in groups and permission obtained from teachers, parents and pupils for videoing and interviewing. Only one pupil declined to be videoed (her face was never recorded).

### *Video review and data analysis*

While we initially formulated the project proposal, the teachers and a departmental colleague in each case committed to collaborate with us throughout the stages of data collection, analysis and validation and development of multimedia outcomes. Crucially, all of their time was funded by the project. One or two volunteer academic subject specialists per case also viewed the videos and offered independent input.

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[5] The Specialist Schools Programme (http://www.standards.dfes.gov.uk/specialistschools/) helps schools, in partnership with private sector sponsors and supported by additional Government funding, to establish distinctive identities through their chosen subject specialisms. Two schools were specialist Technology Colleges, the third was a Business and Enterprise College.

[6] The pilot session prior to each study served to induct our professional camera operator, and assisted determination of camera location and resolution of technical issues such as screen glare and poor contrast.

[7] Soliciting teacher diaries and early interviews concerning planning supplemented, and overcame the potential limitations of the indirect and inevitably selective method of obtaining accurate evidence for teacher thinking through video-stimulated recall (outlined by Lyle, 2003, Powell et al., 2003, Roschelle, 2000).

Assisting the teachers to make explicit their pedagogic rationale was a primary aim throughout the video review (detailed in Appendix 7).[8] **Phase 1** included individual review, analytical commentary and categorisation of strategies and interactions on time-coded grids containing video summaries (Figure 1), plus provisional identification of 'critical episodes'[9] – actions, interventions or pupil-initiated interactions perceived (subjectively) as key in using technology to support learning 'effectively'. Independent review of combined grids **(Phase 2)** followed, then four recorded joint meetings (3 hours each) where we progressively negotiated a consensus account and coding scheme **(Phase 3).** In **Phase 4**, the team identified overarching themes and potential exemplars for dissemination, clarifying selection criteria and negotiating content and structure of multimedia outcomes.

### *Theory building*

Central ideas embodied in sociocultural theory and related to teacher mediation were introduced to the teachers early on via a glossary (Appendix 8) and illustrative episodes. Teachers*'* own ideas resonated with some of the novel terms; one described *funnelling* as "a fantastic word for a very complex, rambling description of something that happened". These constructs formed a basis for collaboratively constructing a coding scheme that encapsulated their application within various settings involving projection technology. During this process, multiple perspectives and interpretations were made explicit, debated, systematically validated and iteratively refined. (See Hennessy and Deaney (in press) on the dynamics of collaborative theory building and video review.)

The video review process offered a powerful methodological tool for capturing the complexity of teaching and learning processes. Viewing episodes multiple times from multiple perspectives revealed salient patterns and complementary interpretations (Lesh and Lehrer, 2000). Coding is never 'theoretically innocent' (Alasuutari, 1996, p.372-3); some initial themes inevitably reflected the researchers' perspective on learning through active participation. Nevertheless, through deconstructing practice within a framework of trust, both researchers and teachers willingly saw activity in new ways and modified their generalised theories. **'**Intermediate theory' was thereby co-constructed. Table 1 lists the main original and emerging terms. The codes were ultimately woven into longer narrative accounts (see Results), illustrated by concrete exemplars.

In sum, the work has developed an approach to collaborating with practitioners as co-enquirers in intensive scrutiny of practice. Our differing professional expertise was mutually respected and deliberately exploited. Digital video critique was an effective catalyst for teacher introspection and team discussion (Armstrong and Curran, 2006, Sheard and Harrison, 2005). This helped us to specify and interpret critical episodes, drawing on theory in characterising underlying pedagogical strategies. *The **unique methodology** of this project is proposed as our first significant contribution to the field; development of the collaborative theory building process itself is a key outcome.*

[8] Lesh and Lehrer (2000) warn that many projects ultimately collect far too much video footage and spend far too little time interpreting the data. We responded by engaging in in-depth critical scrutiny and discussion of each lesson video and related data.

[9] See Powell et al. (2003) on 'critical events'.

## Results

Our second contribution is *grounded 'intermediate theory' embodied within detailed narrative accounts of the themes emerging* from micro-analysis across multiple data sources, both within and across cases (Yin, 1998). These (temporally located) accounts derived from *recontextualising* and refining constructs from sociocultural theory by applying them to specific classroom practices involving projection technology, and *reframing* them using accessible language (essential for engaging teachers: Triggs and John, 2004).

Space precludes reporting in detail the extensive findings from in-depth thematic analyses of 24 lessons across four subjects. However the lengthy narrative accounts are located in the five *Themes_Emerging.pdf* files on the Across Subjects CD-ROM (Downloadable Resources folders), and also segmented within the 'Themes' area of each resource. We recognise that the narratives encompass causally linked assertions (Juzwik, 2006). Thematic interrelationships and hyperlinks to video clips of critical episodes illustrating each theme embedded within 'Themes' accounts introduce a viewpoint on observed events and strategies. Generation of themes and selection of episodes were negotiated by consensus (transcribed meeting notes are available to other researchers for inspection so that our conclusions are traceable to the data: *ibid.*). They were shaped by our research focus (other 'takes' on the data undoubtedly exist).

The across-subjects narrative illustrates the diverse ways in which common themes were manifested. (Individual rather than subject culture differences are highlighted since a single teacher per subject cannot be assumed to be representative.) The **central themes emerging across cases** concerned exploiting projection technology tools via: *creating a supportive environment for active learning (cognitive / physical participation)* during interactive whole class teaching; *supporting public sharing and co-construction of conceptual knowledge* (mathematics, science) *and interpretations* (history, English), e.g. through *collective annotation by teachers and students on the board, communicating and developing complex ideas, modelling thinking / writing processes, scaffolding and personalising using projected images*; *flexibly adapting support and modes of technology use to diverse learning needs, goals and settings; priming for ICT use, and intertwining of ICT and other resources.* (See across-subjects theme map in Figure 2 and breakdown of themes by subject case in Table 2.)

A key affordance of the IWB harnessed here, as elsewhere (e.g. Hennessy et al., 2007), was the ability to revisit stored resources and products of joint activity, including annotated slides, helping to *'reignite' prior learning.* Finally, *student recording of the outcomes of class activity* included use of *'matched resources'*– miniature replications of IWB images (e.g. components of the photosynthesis equation or instructions for a practical investigation). They were used to scaffold learning, save copying, increase 'thinking time' and provide permanent records in pupils' books. This pedagogical strategy was unusual; saving or printing IWB work for later use is an underdeveloped practice. Pupils themselves welcomed such records as memory aids.

Asking pupils to annotate their mini-diagrams or construct *aides memoires* were elements of science teacher Chris's approach that reflected the wider theme of *personalisation*[10]: three teachers

[10] The notion of 'personalisation' we developed was distinct from the recent government focus on 'personalised learning' (although the T-MEDIA multimedia outcomes themselves do address those

saw projection technology as aiding affective and cognitive engagement through *encouraging pupils to visualise themselves in a particular scenario or role or relate a concept to themselves.* Chris described how "you are actually addressing a class of individuals and trying to challenge them individually in their learning. It's just that they are doing it together." This helped learners to actively translate board work into books. For example, pupils drew their own diagrams illustrating how the plant cell wall protects and supports, then shared them by drawing (or projecting their books) onto the IWB.

In English creative use and annotation of visual images by teacher Jackie stimulated pupils' personal understanding of the underlying themes, characters and motivations. Group discussions of a bedraggled hitchhiker image (Figure 3) also helped pupils to formulate and rehearse their thoughts before voicing them with greater confidence during a plenary, illustrating the commonly observed strategy of *priming* for subsequent technology-supported whole-class activity. Similarly, in mathematics, investigative pairwork on laptops served to identify intercepts prior to plenary work on gradient. In English the IWB was sometimes used as a stimulus for ideas underpinning subsequent pupil writing or collage construction – a reverse form of priming.

Two further examples give a flavour of how development of intermediate theory unfolded. First, Chris introduced the idea of a *'learning journey'* in Meeting 2. Construing this as a scaffolded pathway towards achieving new learning, aided by technology, he spontaneously devised a graphical representation of our developing thematic framework in these terms (Figure 4a). This was developed through discussion over time; mapping relationships between themes triggered further insights and reorganisation of our ideas. Comparison of initial and final versions (Figure 4b) highlights changes in our thinking and clustering of emerging themes. *Motivation, rapport* and *feedback* were seen as all-pervasive. These relate to overarching themes *adaptive teaching* and *personalisation.* Chris recognised that responding to learner feedback (often missing from research accounts of pedagogical knowledge) was a key factor omitted from his first diagram and explicitly incorporated it:

> It's about how you react, change, move on the pace, where are [the pupils] in terms of moving towards the new learning. All the time, there's feedback coming from the pupils in all sorts of different ways and that's then informing your thinking on the hoof.

An example of formulating specific 'intermediate theory' terms arose from a meeting discussion about poem writing in the final English lesson. The activity was introduced via a series of slides containing images displayed in previous lessons ("a visual memory jog to remember the discussions") and suggested starting strategies, verbally elaborated (Figure 5). In her review grid commentary, colleague Tina had introduced the notion of Jackie "*drip feeding"* ideas and support (verbally and visually) throughout the lesson. The teachers developed this in terms of a subtle form of visible, optional support, evocatively termed *silent scaffolding*:

> T: I think it's part of scaffolding isn't it? It's just much more subtle and it's a continuous process. . .

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personalised learning strategies identified for teachers which are related to sharing and exchanging practice and developing a wider repertoire of teaching strategies). It is also not to be confused with the individualised learning through ICT use advocated by some policymakers, a notion at odds with learning through collegial interaction, and potentially resulting in formulation of idiosyncratic knowledge (Sutherland et al., 2004).

> J: . . .whilst they are in the middle of doing something rather than before. . .
>
> T: There was something about the SmartBoard being unobtrusive, so as a background. . . it's sort of like a *silent scaffold*, if you like!
>
> J: With visibility for the whole class, a memorable object of joint reference.
>
> [. . . .] T: It's constantly there so there's no fuss. You can just look at it. Nobody knows, it doesn't matter.

This dialogic exchange illustrates how a theoretical concept was co-constructed through extending an existing concept to a new context, whilst capturing the natural language descriptors.

The themes outlined are elaborated via this summary of *how* the English, history and science teachers exploited IWB technology, in particular the affordances of dynamic visual presentation, provisionality and technical interactivity, to support learning by using:

- **multiple resources:** a range of visual images, texts, diagrams, animations, audio / video clips, simulations, quiz, paired statements activity, **flexible camera** in science
- **textual annotation** (labels, thought bubbles, tick/cross, handwriting conversion to aid legibility and/or pupil spelling), especially to facilitate sharing of ideas
- **graphical annotation** (circling, highlighting, underlining, shading) as **analytic tools**, e.g. to render complex ideas and language more concrete and salient or draw attention to particular features
- **focusing e.g. spotlighting, enlarging, zooming, hide and reveal, overlay**, **scrolling**, to investigate detail, orient, maintain attention on key concepts / relationships, reveal "correct" answers, or create suspense
- **drag and drop** for classifying or arranging components (e.g. photosynthesis equation)

In sum, technological resources were employed as publicly visible, manipulable objects, scaffolds and stimuli for thinking, and tools for shared communication. One example demonstrates how Lloyd harnessed some of these interactive features to support his collegial, participatory and dialogic approach to historical knowledge building (which he termed 'interdependence'). Pupils annotated a portrait of the young Elizabeth then others connected these labels with features of the image (Figure 6), thereby "guess[ing] the thinking" of peers [empathy] and "extend[ing] their own knowledge." Lloyd claimed: "We've all come with different understandings of what this means and we've built a more collective… view."

The variation between cases in degree of using technology, groupwork and whole class teaching is summarised in Figures 7-10, which highlight the much greater proportions of whole class teaching without ICT and of small group work in mathematics. That case illustrated *'adaptive teaching'* – continual re-evaluation and dynamic modification of practices in light of informal assessments of students' motivation, participation, learning needs and progress (Randi and Corno, 2005). Sarah embraced a wide diversity of individual differences, continuously responding to these. She designed highly participative activities and pairings where learners with different profiles or styles could work together productively. She brought into play *multiple software tools suited to different purposes* including graphing software (used in whole class mode via tablet PC and projector or on laptops), online games and models, spreadsheets, and assessment quizzes using a class response

system with individual handsets. Further strategies emerging included *capitalising on unexpected outcomes / errors (some technology-stimulated)* and *managing technology use.*

### *Impact on pedagogical thinking and practice*

All participating practitioners described *positive impacts of reflecting in depth on practice and working with educational theory.* This included re-evaluation of the degree of technology use and the kinds of pedagogy it serves. Lloyd reported:

> Thinking about the lessons has made me go back to some fundamental questions: who makes the history in the classroom? Where does the dialogue start from, where does it end? And who owns what we take as most important out of the discussion?
>
> I really enjoyed [teasing out] the differences between different types of 'dialogic' and... it's something I can reflect on and use in planning my teaching. . . .it's almost like the codes were becoming used by me, for my own purpose.[11]

Applications to teaching other topics and subjects were mentioned. One pair uses selected parts of our co-constructed coding scheme as a whole school lesson observation schedule (Appendix 9), feeling that focusing on dialogic interaction promotes deeper analysis and clarifies teacher thinking about observed lesson activity. They work with colleagues in other subjects and have presented at two practitioner conferences.

Another teacher reduced her dependence on the IWB and modified her approach for a class who "liked to trial things a little bit more physically." She reported "using the whiteboard as a prompt but then going back to some more traditional drama [role play] in the English classroom." Her colleague added:

> You are striving to improve your own practice through taking part in something like this... It makes you rethink completely the whole approach that you take to teaching, and if you have the [IWB] facilities available then you would certainly use them to a fuller capacity than before.

The science teacher described his project involvement as

> the most intensive personal reflection that I've been through for a long time... it's really good INSET to actually reflect at great depth and have to justify [your] reasons. . . .that itself has had a very significant impact, moving to this level of metacognition, and becoming more and more aware of not just thinking, but then standing back and saying 'Why am I thinking that?' So the process was very useful, not just in planning for teaching though, but in preparation for being a Deputy Head. . . .it's had a broad impact upon [my] general level of thinking.

[11] This resonates with recent work by de Freitas *et al.* (2007, p.12) illustrating practitioners' adeptness at repurposing pedagogical models to suit their own contexts, concluding that "teachers learn to talk the talk of educationalists by making sense of the artefacts [they] provide".

## Outputs

A substantial **article** by Hennessy and Deaney describing the collaborative theory building process has been accepted by *Teachers College Record* (a nominated output). Another **article** (for the *Curriculum Journal)* describing the history teacher's democratic approach to IWB-supported teaching and learning of historical thinking processes is almost complete.

Interim stages and outcomes of the work have been presented at several **conferences**, detailed at the end of this report. Interview transcripts and video summaries were submitted to the Data Archive.

### *Multimedia tools for professional development: Aims*

The emerging pedagogic strategies are embodied in a set of interactive CD-ROMs for dissemination to practitioners, trainees, mentors, heads of department, teaching and learning coordinators, advisors, teacher educators and researchers. *These tools constitute our third contribution – direct application of the findings to educational practice.* Their **aims** were to:

- highlight key issues emerging from our joint analyses and exemplify strategies and contextual conditions for success, including integration with non-digital resources and activities;
- use video clips and narrative to illustrate how projection technology can potentially be exploited to enhance collaborative construction of subject knowledge – in ordinary classrooms with students across the attainment range;
- make this practice accessible and meaningful to other practitioners; build bridges with viewers' own experiences and 'practical theories';
- stimulate debate about alternative pedagogical approaches and 'added value';
- develop user confidence to try out new approaches and provide examples of teaching resources.

These aims are consonant with our clear statement from the outset to participants and audiences of the research that our *video-based materials are not intended to provide prescriptive models of 'best practice'.* Not only are those often considered 'staged' by teachers, but international comparative research using video (NRC, 2001) indicates that (a) it is unrealistic to assume we can identify 'best' or 'effective' practice and precise elements to be imitated (this necessitates establishing an empirical link with learning gains), and (b) we should consider other contextual factors, including pupil group attributes. Moreover trainees can be demotivated by seeing flawless expert practice. Instead we provide video exemplars of authentic situations for discussion, capitalising on their power to "help teachers to imagine new approaches, to rethink what they might otherwise take for granted..." (*ibid.,* p.20).

We recognised that video alone can lead to unfocused sampling and is insufficient in supporting reflective dialogue. Lesh and Lehrer's (2000) assertion that "video draws its power from the interpretive framework established by researchers" (p.673) was borne out. The framework was, however, co-constructed with practitioners and then drawn upon in constructing the built-in guiding

activities. Issues for user discussion reflect some external constraints and tensions arising, e.g. the balance between pupil and teacher manipulation at the board, and advance versus real time construction of resources with learners.

**Suggested uses** are by groups of colleagues or educators debating approaches and issues with groups of practitioners, or by individuals, reflecting on the materials, and optionally recording thoughts to share.

### *Design and content*

There are four individual subject CD-ROMs and an overarching one presenting excerpts and themes emerging across cases. A 2-disc compilation pack contains all five resources (our second nominated output).

Each CD includes (12-21) video clips, 2-9 minutes long. Each has a clip introduction plus related commentary and materials (see screen shot in Figure 11):

- Teacher commentary on the episode (from teacher's and colleague's grids, relevant diary and interview material)
- Researcher commentary (from grids)
- Further commentary from subject specialist/s, team discussions, pupil perspectives occasionally
- Suggested alternative approaches
- Issues / prompts for discussion and reflection

Downloadable lesson resources, pupil work, whole lesson video summaries plus screen displays are available. Perceived 'added value' of the technology and qualitative evidence (teacher / pupil accounts) for learning in each lesson are documented.

We drew on our collective intuition – supported by research (Sheard and Harrison, 2005, Sorensen et al., 2006) – that presenting multiple hyperlinked resources and allowing *flexible access according to users' own motivations and interests,* is most successful for professional development. Users can obtain a lesson sequence overview and information about participants or methodology before viewing videos either chronologically or navigating selectively via an interactive map of technology features (hyperlinked to exemplifying clips: Figure 12), or a clickable map representing pedagogic themes and links. Other material available includes a glossary of terms used and references to literature / other resources.

Resource design and content were heavily influenced by teacher suggestions concerning these and other key features, including 'pop-up' still images / slides accessible alongside clips, some clips showing no technology use, and occasional footage from the second camera integrated to reduce teacher focus. (See further design decisions in Appendix 10.)

Technical issues arising in representing complementary interpretations of a single video record using hyper-media are outlined in Appendix 11. Finally, we recognise that viewers may bring new

levels of meaning and different interests. Our already layered interpretations must remain open to new interpretations and contexts (Goldman-Segall, 1995), and to continued theorising and testing rather than imparting "recipe knowledge" (Alexander, 1984). The emerging strategies themselves remain fluid and subject to adaptation by other practitioners (de Freitas et al., 2007). Prototypes were piloted with academic and practitioner colleagues, including student teachers, and commentary continues to be welcomed.

## Activities

The award holder is a founding member of the **IWB Pedagogy Research Group (IWBPRG)** formed at BERA 2005 (chaired by Steve Kennewell), comprising eight UK and two international teams meeting regularly to develop, debate and disseminate research-based knowledge concerning pedagogy and learning with IWBs. T-MEDIA work has been presented as part of IWBPRG symposia at three national conferences; the CD-ROMs were launched nationally at an IWBPRG session at BERA 2007. Two further group symposia have been proposed by the award holder to the American Educational Research Association, NY, March 2008. The group has also produced a special issue of *Learning, Media and Technology* (September 2007).

## Impacts

The Dissemination section of the form indicates the significant degree of interest already expressed in the research by academics, practitioners, trainees and teacher educators. We anticipate that outcomes will be widely used (CD-ROMs have already been requested by four Antipodean organisations), influential in initial and in-service teacher training, and welcomed by policymakers seeking an investment return. They also offer guiding principles for designing further video-based activities that move away from 'best practice' models.

**User comments:**

*"It shows the power of the whiteboard and the versatility... how you can engage a whole class."*

*"It's certainly a tool that as a mentor I would use with trainees."*

## Future Research Priorities

A key priority is identifying the pedagogical approaches to using projection technology that provoke more interactivity, learner participation and agency, including group activity. Will the increasing prevalence of remote input devices increase opportunities here? How do learners themselves perceive and orchestrate classroom interactions?

A series of pioneering pilot case studies investigating how teachers with an established 'dialogic' approach to teaching can exploit interactive features of the IWB to support learning is already planned (with Prof. Neil Mercer) within the award holder's ESRC Research Fellowship work (employing the CD-ROMs as stimuli for teacher reflection). It would also be useful to trial our prototypes more widely, and develop them further accordingly.

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## Conference presentations

S. Hennessy, R. Deaney & K. Ruthven.
**Developing pedagogical expertise for integrating use of the interactive whiteboard in secondary science.**
Paper presented at Keynote Symposium on *Developing Pedagogy for Interactive Whiteboard Use* at the Annual Conference of the British Educational Research Association (BERA), Glamorgan, September 2005.

R. Deaney, S. Hennessy & K. Ruthven.
**Teacher mediation of technology-supported graphing activity: a video-based case study.**
Paper presented at the 30th Annual Conference of the International Group for the Psychology of Mathematics Education, Prague, July 2006.

S. Hennessy & R. Deaney.
**Integrating multiple teacher and researcher perspectives through video analysis of pedagogic approaches to using projection technologies.**
Paper presented at Symposium *on Methodology for Researching Interactive Whiteboard Use* at the Annual Conference of the British Educational Research Association (BERA), Warwick, September 2006.

S. Hennessy & R. Deaney.
**Fostering participation of learners using interactive whiteboards.**
Invited presentation at Becta ICT Research Network Annual Conference, Birmingham, November 2006.

S. Kennewell.
**Reflections on the interactive whiteboard phenomenon: a synthesis of research from the UK.**
IWBPRG synthesis presentation at Australian Association for Research in Education conference, Brisbane, December 2006.

S. Hennessy & R. Deaney.
**Fostering participation of learners using interactive whiteboards.**
Paper presented at 9th ITTE (Information Technology in Teacher Education) Research Seminar, Cambridge, February 2007. Also co-leader of **Discussion Forum on Implications of IWB Research for Teacher Education.**

S. Hennessy & R. Deaney.
**Multimedia tools to stimulate practitioner thinking and reflection on using interactive whiteboards in the classroom.**
Paper presented at Symposium on *Interactive whiteboards: Issues relating to professional development and pedagogical change (Part II)* at the Annual Conference of the British Educational Research Association (BERA), London Institute of Education, September 2007.

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S. Hennessy & N. Mercer.
**Exploiting interactive digital technology to enhance dialogic classroom interaction.**
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*Table 1.*
***Terminology emerging from intermediate theory building process (across subjects)***

| Formal theory | Intermediate theory |
|---|---|
| dialogic interaction | dialogic class discussion, dialogic peer discussion |
| dialogic communication (non-interactive) | dialogic synthesis |
| scaffolding<br>coaching<br>responsive assistance | drip feeding, injecting information, feeding in ideas, silent scaffolding, use of keywords<br>clarifying parameters, constraining tasks, stepped revelation, avoiding alienation, provoking conflict<br>filling in (diagnosed gaps in knowledge)<br>shaping and reshaping thinking, revoicing<br>learning journey |
| fading<br>shifting responsibility | deferring response, hide and reveal (withholding and timely release of teacher knowledge)<br>giving responsibility / ownership to learners<br>active involvement, vicarious involvement |
| focusing | focusing on correct / salient part of response<br>annotation, highlighting patterns / similarities / differences / links<br>illustrating progress / orienting<br>scene setting / priming for forthcoming activity / centring<br>rehearsing ideas (individually or with peers before class activity) |
| tailoring to learners' skills and interests | empathy or personalisation<br>relevance (socially contextualising)<br>challenge<br>targeting / calling on individuals<br>differentiation |

| | |
|---|---|
| articulating<br>intersubjectivity<br>guided participation | interdependence, public sharing, public dissemination, teacher relaying pupil views to class / individual / group<br>peer collaboration – 'phone-a-friend', peer tutoring and direction<br>encouraging expression of different ideas / highlighting diversity<br>showcasing pupil work<br>supportive learning environment<br>collaborative construction of knowledge<br>collegial, inclusive, democratic classroom culture<br>pupil as expert, teacher as learner, giving status / value to pupil contributions |
| reflecting<br>exploring | encouraging analytical / independent thinking<br>supporting exploration, prediction and verification<br>capitalising on unexpected outcomes and errors |
| fostering generalisable skills<br>modelling | developing tools for learning / remembering<br>transferable skills |
| consolidating and reinforcing | reigniting / revisiting prior learning (and annotations)<br>mini-plenaries (interspersed throughout lesson)<br>aide memoires, matching digital resources with miniature paper copies<br>intertwining technology / paper resources, corroborating manual methods<br>use of multiple resources |

*Note.* There are some inter-relationships between categories, and the intermediate theory column contains sets of emergent codes related to – not necessarily directly defining – the formal terms listed; there is no definitive 1:1 correspondence. Many of the formal terms listed were themselves adopted and used on some occasions in addition to being replaced or elaborated through use of the new terms depicted in column 2. In particular, dialogic interaction, scaffolding and fading were terms very often employed by teachers. Likewise some terms not listed (funnelling, authoritative interaction, modelling, affordances, zone of proximal development, assistive questioning, spiralling) were adopted and used without modification. (Further emergent codes were concerned with planning and task structuring, lesson pacing, managing use of technology and so forth but space precludes listing them all here.)

*Table 2.* ***Themes emerging by subject case***

| THEME | English | History | Maths | Science |
|---|---|---|---|---|
| **Supportive environment for collaborative working** | Co-construction | Co-construction<br>2nd order concepts<br>Collegiality | Public sharing | Public sharing |
| | Focusing & making connections | Focusing & making connections | Focusing & making connections | Focusing, Orienting<br>Equation<br>Knowledge building |
| **Stimulating active learning & dialogic interaction** | Interactive teaching<br>Dialogic interaction | Active learning<br>Dialogic interaction | Active learning<br>Dialogic interaction | Active learning<br>Explore & verify<br>Dialogic interaction |
| | Vicarious involvement | Hands-on P use of ICT<br>Vicarious involvement | Hands-on P use of ICT<br>Vicarious involvement | Hands-on P use of ICT<br>Vicarious involvement |
| **Adaptive teaching** | Scaffolding & fading<br>Transferable skills | Scaffolding & fading<br>Transferable skills | Adaptive teaching<br>Scaffolding & fading | Stimulating thinking |
| | Visual images | | Multiple resources | |
| | Personalisation | Personalisation | Exploiting errors | Personalisation |
| **Intertwining resources** | | Intertwining resources | Intertwining resources | Intertwining resources |
| | Rehearsal, priming | Rehearsal, priming | Rehearsal, priming | Rehearsal, priming |
| **Recording & revisiting** | Revisiting<br>Smooth & turbulent lesson flow | Revisiting | | Aides memoires<br>Matched resources<br>Revisiting |
| **Planning & managing** | Planning<br>Lesson flow | | Managing technology use | Planning & structuring |