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Eliciting situated expertise in ICT-integrated mathematics and science teaching

FINAL REPORT TO ESRC 2004

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SET-IT Project: Full Research Report

Background

This research aimed to elicit the teaching expertise involved in productively integrating use of information and communication technologies (ICT) into classroom practices in secondary-school mathematics and science.

The research literature shows that experts have acquired intuitive specialist knowledge to meet the demands of everyday situations (Ericsson and Smith, 1991). Such ‘knowledge in action’ is interwoven with the social, physical and cultural context in which activity and learning take place (Brown *et al.*, 1989). Thus, expertise is tuned to the setting and shaped by structuring resources available in the situation (Lave, 1988). Equally, expertise incorporates an important degree of flexibility and the capacity to respond to the uncertainty and contingency which are normal in real life situations (Wynne, 1991).

When digital educational technologies are introduced into school settings, mathematical and scientific knowledge are recontextualised and restructured (cf. Wynne, 1991). Likewise, pedagogic expertise is adapted to the constraints imposed and the benefits perceived (Wertsch, 1998). By examining practitioners’ expertise across a range of classroom settings we have been able to analyse and understand how teachers adapt and reframe their actions and goals in appropriating the use of ICT. In addition, we have examined how teachers seek to respond to uncontrolled factors – such as unanticipated pupil responses and organisational constraints.

The naturalistic tradition of research underpinning the theoretical orientation of this study seeks to access the complex ‘craft knowledge’ of practitioners through eliciting teacher accounts and interpretations of their own pedagogic practices (Brown and McIntyre, 1993). Our approach to research involves ‘reverse engineering’ subject pedagogy (Ruthven, 2002) so that practitioners’ expertise can be elicited and codified, thus furthering the development of scholarly knowledge about teaching.

Such research is highly pertinent to current policy and practice. Judgements from school inspection reports regarding the development of ICT use in Mathematics have remained negative, concluding that “despite significant government funding, the use of ICT to promote learning remains a weak and underdeveloped aspect of provision” (Ofsted, 2004b, p.4). In Science, however, official judgements have become more positive over time, so that “the competence of science teachers to use ICT… in the classroom to promote pupils’ learning is good or better in over four fifths of schools” (Ofsted, 2004a, p.4).

Given that “the best practice is excellent but it is not shared widely enough” (Ofsted, 2004a), our study aims to make a more strongly analytic contribution to such wider sharing, responding to the call for prioritising identification of pedagogic strategies and principles underlying successful practice (Becta, 2003; DfES, 2003), and addressing the need for “well informed, shared approaches to a few significant and effective applications in various areas of the curriculum, which are clearly documented to show why they are winners” (Ofsted, 1999).

Objectives

The study has been successful in its overarching aim of *identifying, documenting and analysing several exemplary cases of a range of established teaching practices which integrate use of ICT in supporting the teaching and learning of mathematics and science,* as follows.

Our approach to *identifying* exemplary cases was as follows. First, through seeking expert recommendations, and then cross-checking them, we identified (52) subject departments where exemplary practice might plausibly be found. Second, through conducting focus group interviews with members of (21) subject departments, and then examining the extent to which different forms of ICT use were endorsed, and in what terms, we selected (5) promising teaching practices for further investigation. Finally, through identifying which teachers had been particularly articulate about each chosen form of ICT use, we assembled a structured portfolio of (19) teacher-practice cases, considering also the potential for illuminating comparisons. At each stage, of course, the participation of departments and teachers depended on willingness and feasibility.

The five practices chosen for investigation were: use of (1) dynamic geometry, and (2) graph plotting, both in mathematics; and use of (3) multimedia simulation, (4) data capture and analysis, and (5) interactive whiteboard, all in science. Further detail on the portfolio of cases is provided in Annexe 4, and on the selection process in the Methods section and Annexes 1, 3.

Our approach to *documenting* cases involved observing two lessons for each teacher/practice case, and conducting post-lesson teacher and student interviews to elicit participants' thinking about the lesson (as detailed under Methods). Through these interviews, the study has been successful in achieving its objectives of *stimulating the teachers and the students involved in these exemplary cases to articulate, and reflect on, their models of how use of ICT is supporting teaching and learning.*

Finally, our approach to *analysing* the cases of each practice, individually and collectively, was as follows. After initial familiarisation with the range of material related to a practice, teacher interview transcripts were analysed through a recursive process involving the development and refinement of a system of codes, aiming first to capture the ideas expressed about each particular lesson, and then to draw together related ideas across interviews by organising them thematically. Lesson observations and other material were used to amplify and refine analysis of some themes, particularly where it either illuminated or extended teachers' accounts. The study has thereby been successful in achieving its objectives of *eliciting, identifying and representing the situated expertise guiding teaching in these exemplary cases*, and *conducting cross-case, within-practice analyses aimed at identifying transposable components and situational variants in pedagogy.* The two research products accompanying this report present such analyses.

Methods

In this section, we detail the processes of case identification and selection, and of data collection and analysis, with pointers to supporting Annexes.

In **Phase 1**, a process of multiple recommendation and reference (informed by academic colleagues, subject advisors, practitioners and school inspection reports) was used to identify subject departments regarded as relatively successful in terms both of the general quality of the subject education that they provide, and of the integration of ICT into their practice (see Annexe 1). Enquiries yielded far fewer unequivocal recommendations than anticipated, but eventually provided a suitable field of schools located within 125 miles of Cambridge.

In **Phase 2**, semi-structured focus group interviews were conducted within 11 mathematics and 10 science departments where three or four key users of ICT were invited to nominate and describe, from their experience, examples of successful ICT-supported subject practice (see schedule in Annexe 2). Through a process of review, which took into account the prevalence and commonalities of these examples, a smaller number of teaching practices were selected for more intensive investigation (see Annexe 3). Priority was given to forms of ICT use which were widely reported as positively enhancing specific aspects of student learning; this led, for example, to a decision not to examine the use of spreadsheets in Mathematics, given that teachers primarily represented them as increasing the efficiency of classwork across a range of topics. Equally, priority was given to forms of ICT use seen to be in tune with the developing curriculum.

In **Phase 3**, teachers who had been particularly articulate in support of a selected practice were invited to help us to gain greater insight through participation in case studies during **Phase 4**. The aim was to work with several teachers engaged in the same practice, in different settings, varied by school, pupil group, and topic. Alterations to teaching schedules and other organisational factors precluded some willing teachers from taking part (see section 6), and eventually 11 science and 8 mathematics case studies (a minimum of three cases for each of the five practices) were undertaken across 11 schools (see Annexe 4). All of these schools had specialist status; six were designated as Leading Edge schools.

This process produced a range of sources of evidence about each practice. First, material relevant to each of the chosen practices was extracted from the transcripts of the departmental focus group interviews conducted in Phase 2. The main sources of evidence were gathered through two lesson observations and post-lesson interviews. Each observed lesson was audio-taped, and together with lesson materials, digital photographs, samples of students' work, and researchers' notes, an observation record of each lesson was compiled. Following each observed lesson, two semi-structured interviews were conducted, one with the teacher, and another with a group of six students (aged 11-16, selected by the teacher from across the academic range). Printed prompt cards were displayed and discussed in sequence (see Annexes 5 and 6). These prompts were intended both to provide participants with a focus for reflection and reference, and to standardise data collection within and across cases. In particular, the teacher interviews were designed to elicit their thinking about key actions in making the use of ICT successful; the student interviews elicited their thinking about how technology use and teacher action contributed to their learning. All observation and interview techniques were piloted in relation to each subject.

The main analysis of each practice (**Phase 5**) followed intensive preliminary reading of the available material. Analysis of the post-lesson teacher interview transcripts for that practice was then undertaken by importing them into a computerised database designed to assist the coding and retrieval of material (QSR*NUDIST and HyperResearch were employed). First, open coding of a teacher's ideas about a particular lesson was carried out; this was followed by axial coding of similar material across lessons, through an iterative process of constant comparison (Glaser and Strauss, 1967), directed towards a thematic organisation of ideas (see sample coding scheme in Annexe 7). Observed teaching episodes, pupil perspectives and in particular, earlier departmental focus group data, were used to refine analysis of some themes, especially to illuminate or extend teachers' accounts. Drawing on the analytic approach of Yin (1998), these within-practice, cross-case analyses aimed to identify transposable pedagogic principles as well as situationally specific ways of realising ideas shared by different practitioners engaged in similar practices.

The *ethical guidelines* of the British Educational Research Association (available at http://www.bera.ac.uk/guidelines.html) were adhered to throughout the project. Schools, teachers and pupils were offered anonymity and all potentially identifying information was removed from any data records which might be externally viewed or included in reports and presentations.

RESULTS

Mathematics

The rationales which teachers advanced for nominating many ICT tools emphasised their capacity to increase the ease, speed and accuracy with which routine mathematical tasks could be carried out, allowing attention to be focused on the key mathematical ideas at issue. We chose graph plotting and dynamic geometry for closer investigation because the rationales offered for their use went further, highlighting the way in which the relative immediacy of feedback in the computer medium helped to create a more interactive sense of the relation between the modification of an equation and change in its graph, or the dragging of a figure and change in its measures.

Teachers saw both types of software as assisting them in adopting an investigative approach to key curriculum topics. Lessons were designed around carefully structured and controlled mathematical situations, intended to maintain focus on target properties. At some times the whole class was led by the teacher; at others, pupils worked, often in pairs, at their own machines, guided by printed worksheets and teacher interventions. While teachers reported that ICT (compared with pencil and paper) was particularly successful in making more active and investigative approaches viable with classes of lower ability, they structured lesson tasks to a greater degree for such classes, and were particularly concerned with the straightforwardness of software. An important factor contributing to this concern was the relative infrequency with which each software package was used; typically a few times a year per class, affecting the technical proficiency which pupils could be expected to develop and retain.

Teachers reported employing a range of strategies to introduce pupils to required techniques and help them recall them, including:

- step-by-step whole class demonstrations;
- step-by-step printed instructions, including screen images and/or keying sequences;
- coaching individuals/pairs, sometimes on new techniques in response to emergent needs;
- promoting free exploration of facilities by pupils, followed by plenary reporting and teacher moderation of new techniques. Equally, teachers were alert to the ways in which the availability of projection and printout facilities could contribute to effective communication and recording of examples.

Use of graph plotters in treating relations between equations and graphs

Archetypical practice involved using graph plotters to examine the relationships between equations and graphs, notably through exploring the effects of changing the coefficients of equations on their corresponding graphs. Most frequently mentioned were linear and quadratic graphs.

Teachers were sensitive to the part that attention to individual points played in underpinning the sense of a graph as a rule-governed set of coordinate pairs; this led them to draw pupils' attention to the relationship between individual points and whole graphs when they judged such underpinning to be necessary. Equally, tasks were carefully structured so that pupils gained experience of modifying and varying the numerical coefficients of an equation before the use of literal parameters was introduced.

Graph plotters were seen as relatively readily usable by pupils. Teachers were alert to important variations in the features provided by different packages, and to how the availability and accessibility of such features could contribute to effective teaching, learning and problem solving:

- zooming and other rescaling operations to capture a graph in the graphing window;
- colour coding to highlight association between equation and graph;
- tabulation facilities and trace displays to establish a pointwise perspective on graphs;
- grid markings to highlight gradient as ratio of vertical to horizontal components;
- dynamic editor to structure the incrementing of coefficients treated as parameters;
- flexibility of permitted equation forms, to widen the range of graphs examinable, and minimise demands of symbolic manipulation.

In lessons where tasks were posed in relatively unconstrained terms (or where pupils breached the specified constraints), the examples chosen and the questions posed by pupils sometimes led teachers into mathematical argumentation which went beyond the controlled examples typical of work with pencil and paper (such as when pupils chose coefficients with very large or small magnitudes, or examined the equations defining implicit functions. Here, teachers' sound understanding and effective exploitation of graph plotters (for example, to rescale and superimpose) sometimes played an important part. This evidences an important mediating influence of technology on mathematical-pedagogical activity.

Use of dynamic geometry in treating angle properties of shapes *(see attached paper)*

Archetypical practice involved using dynamic geometry to examine the angle properties of shapes, notably through dragging figures to generate multiple examples and detect invariant measures; topics frequently mentioned were vertically opposite, supplementary, corresponding and alternate angles; angle sums of the triangle and other polygons; and angle properties of the circle.

Dragging of figures was used to evidence properties in two ways. Most commonly, it was employed to examine multiple examples or special cases of a geometric figure, without attention to variation during dragging, other than in evoking the multiplicity of possibilities. Occasionally it was used to examine dynamic (non-)variation in a geometric figure during the dragging process. Regardless of the type of dragging employed, consideration of geometric properties was almost always mediated by the effects of dragging on numeric measures.

In lessons on one particular topic, the visual presentation and sequential organisation of material were particularly strongly shaped by adoption of a dynamic approach; in particular, teachers were observed to incorporate episodes into their lessons in which the distinctive 'dynamic' image on the screen was (tacitly) related to the more customary 'static' image which students would subsequently encounter when tackling exercises on the page.

In general, teachers saw dynamic geometry systems as relatively difficult for pupils to use for themselves. In departmental interviews, this was reported as a disincentive to use. In all the cases studied, teachers reported, for example, that pupils experienced difficulty in selecting elements within figures reliably; consequently, one teacher prioritised introducing pupils to techniques for simplifying figures through deleting spurious points and lines. Indeed, one teacher (working with lower ability classes) used only class demonstrations, while others limited direct pupil use largely to dragging prepared figures.

Where teachers did expect pupils to construct simple dynamic figures for themselves, an important motivation was the idea that pupils' thinking was shaped by the mathematically disciplined character of the software. Equally, while some teachers sought to protect their pupils from situations where the results produced by the software diverged from expectation (such as in measuring reflex angles, or in summing rounded measures), other teachers saw such incidents as providing opportunities for mathematisation, and for instilling a critical attitude to computer results.

Science

Teachers perceived the use of multimedia simulation, data logging and interactive whiteboards to offer a range of significant, technology-specific, advantages over alternative forms of practical work or textbook use in addressing key curriculum topics, as summarised separately below. Their rationales converged on one major theme where these technologies proved particularly powerful, namely that of *exploiting interactivity and dynamic visualisation in rendering underlying scientific concepts and processes salient for learners.* In each case the technology offered a *manipulable object of joint reference* for teachers and pupils (or peers).

As in mathematics, lessons were designed around examination of carefully structured and controlled situations, intended to focus attention on the phenomena of interest whilst guiding pupils in exploring the consequences of manipulating variables or interpreting results. The key pedagogical strategies emerging included:

- careful preparation, selection and adaptation of resources
- focusing – constraining the domain; accentuating key concepts and underlying relationships
- using real life examples; articulating and challenging everyday beliefs; discussing and reformulating shared experiences and linking them with scientific explanations
- building up and linking conceptual knowledge over a series of lessons; consolidation and application
- pre-empting perceived pitfalls of the technologies

Mode of use of each of the technologies varied across the cases and within lessons, incorporating: teacher-led demonstration, introduction, exposition and recap; individual/ pair work by pupils at their own machines, guided by printed worksheets and teacher interventions; interactive whole class teaching, typically using question-and-answer and projected visual aids as stimuli.

Use of multimedia simulation to explore physical and biological processes *(see attached paper)*

The five cases studied employed simulations relating to three topics: terminal velocity, light mixing, and osmosis and diffusion. The ways in which participating teachers perceived this powerful tool to support science learning corroborated those previously reported (e.g. Baggott and Nichol, 1998; Osborne and Hennessy, 2003). Simulation offered opportunities for pupil exploration and experimentation, along with idealised, dynamic and visual representations of physical phenomena and experiments which would be dangerous, costly or otherwise not feasible in a school laboratory.

Technology use was integrated (and sequenced) in various ways with complementary practical work, theory exposition and plenary discussion. Different teachers also structured activity and supported learning in diverse ways, as exemplified through two contrasting case studies involving a ‘terminal velocity’ simulation. One teacher engaged in whole class interactive teaching, employing the projected simulation as a visual stimulus for pupil questioning and reasoning and hence as a tool to support ‘dialogic’ communication (Mortimer and Scott, 2003). He mediated its use through collaborative testing of pupils’ hypotheses, attending to everyday beliefs, and reconciling these with observed outcomes and scientific explanations. In another case, pairs of pupils manipulated the software but were confined by tightly structured tasks. The teacher valued ‘learning by doing’ but in practice articulated the science underlying the observed motion rather than building on or supporting testing of pupils’ own ideas. Such worksheet-driven lessons were typical across our sample and presented little opportunity for pupil reasoning. Over-structuring of tasks plus pressure to 'cover' an overloaded curriculum meant that the rhetoric of 'discovery learning' in the simulations literature, and teachers' own aspirations to balance student experimentation with use of structured tasks, were not borne out. The constraints on teachers can obstruct them in providing effective guidance and timely intervention to multiple pupils working in 'hands on' mode. We concluded that pedagogic expertise for using multimedia technology effectively can be adapted to situational constraints via interactive whole class teaching which supports scientific knowledge building through engaging pupils in collaborative investigation, articulation and critical scrutiny of persistent everyday conceptions.

Use of technology for data capture and analysis

Recording and handling experimental data through use of sensing equipment is part of the statutory science curriculum but despite widespread acknowledgement of its potential benefits in supporting pupil investigations inside and outside the classroom, demonstration remains the common mode of use (Finlayson and Rogers, 2003).

Use of data logging was teacher-led in all of our four case studies and involved pupils in two types of activity: a) interpreting cooling curves during studies of energy or earth materials and b) interpreting and emulating distance-time graphs in lessons on motion. Teachers viewed the technology as enabling pupil attention to be focused on science through alleviating laborious data collection and graph production; they aimed to harness it to support development of pupils' observational and analytical skills and, in the motion activity, to facilitate learning through kinaesthetic engagement. Dynamic graph display was perceived as aiding conceptualisation by providing a tangible representation of abstract concepts, and immediate feedback enabled actions to be monitored and adjusted. Teachers had developed efficient practical routines in which data logging approaches were used alongside other practical and written work to offer additional perspectives and reinforce understanding, though the balance of lesson activities was configured and managed to suit particular groups, for example through providing different levels of pace, challenge and explication.

Enabling interaction with data whilst the activity is current rather than after the event (as is often the case when lesson time is spent in manual graph production), was seen as motivational for pupils and beneficial to their learning; teachers typically used the projected display to stimulate whole-class discussion of results. Real-time plotting supported use of prediction to capture pupils' interest and focus on outcomes. Such prediction was also regarded as helpful in guarding against pupils' tendency to overly rely on the trustworthiness of computer-generated data by encouraging them to scrutinise output and question anomalous results. It was considered important that pupils should understand how logged data is being generated and teachers used a variety of techniques including metaphor and practical example to show how data collection and display related to the entity being investigated. Familiarisation, rehearsal and contingency planning were regarded as key to successful use of the technology.

Use of the interactive whiteboard to support whole class teaching

Interactive whiteboards (IWBs) have more than tripled in number in secondary schools during the course of this 2-year project. Research is in its infancy but IWB use is believed to improve teacher-pupil interaction through promoting effective questioning (DfES, 2004). *Pupil manipulation* potentially offers opportunities for collective scientific knowledge building. However, recent work with primary teachers (Kennewell, 2004) found that their use was reinforcing a teacher-centred pedagogy. Our four case studies investigated use in these areas: terminal velocity; horizontal projection and collisions; Newton's third law of motion and gaseous exchange at the alveoli; food webs and ecology fieldwork preparation.

Our forthcoming paper details situational variation while some common cross-case themes emerging are outlined here. *Banks of teaching resources* related to each curriculum topic are being built up, drawing on everyday examples plus presentations, animations and video clips painstakingly selected from Internet, CD-ROM and other sources. IWB software significantly facilitates organisation and presentation of resources and instantaneous transition between them. *Continual access* to the whiteboard proved essential for building up competence and confidence; teachers had begun to move beyond a presentation/demonstration ('blackboard') mode towards more discerning and purposeful use which exploits interactivity, provisionality and annotation. This shift resulted in *whiteboard dependence* whereby IWB use had become fully integrated ('an organic part of my teaching process') and unavailability provoked insecurity.

Teachers and pupils unanimously agreed that active *pupil manipulation* of objects on the IWB was beneficial – in terms of motivation, involvement in constructing graphical representations and a related increase in understanding. A comfortable atmosphere was engendered to foster collaboration and overcome pupil reticence, albeit with only partial success. However limited opportunity for physical participation by learners was actually observed in most lessons and little evidence of planning for this or of attending to pupils' own ideas emerged. Teachers asserted that IWB use for whole class teaching generated more opportunities than 'blackboard' teaching for *interaction with pupils* during interspersed individual/group work; pupils valued such teacher assistance, although these interludes did not allow learners to exploit features of the IWB. Realising the potential of ICT is generally a slow, evolutionary process (Hennessy *et al.*, 2005; Kerr, 1991); existing pedagogical approaches and thinking appear to be shaping IWB use, whereby previous lesson plans are 'tweaked' to incorporate a broader range of more exciting, interactive multimedia content. The *IWB significantly enhances rather than transforms classroom practice,* particularly lesson preparation, although teachers recognised the scope for further exploitation of its unique features.

Conclusion

Our observations of worksheet-driven simulation use and teacher-led data logging activity whereby expected relationships are simply verified, coupled with theory teaching via teacher-controlled use of the interactive whiteboard, collectively indicated that ICT use is being shaped by the established culture of school science, where little genuine 'investigation' takes place and the pedagogic emphasis is on covering the syllabus in preparation for examination (Donnelly, 2000). Teachers reported that curriculum time constraints obstructed pupil use of data logging equipment due to set-up time needed, 'playing' with simulated variables, and desired extension of IWB work. These findings reflect a systemic subject culture which is, initially at least, subsuming new interactive technologies by using them mainly for demonstration. However some practitioners employed interactive whole class teaching methods in eliciting, testing and challenging pupils' own conceptions, and building scientific knowledge through discussion and synthesis.

Concluding remarks

We have characterised a range of exemplary teaching practices which integrate use of (rapidly changing) ICT in supporting the teaching and learning of mathematics and science. Some general principles have emerged, along with some ways in which teachers configure technology activities to fit their own settings. The tools we studied were designed to support particular pedagogies, and the literature likewise assumes that these offer opportunities for pupil manipulation, experimentation, discovery and reasoning. While teachers endorse such use in principle, it is not always realised in practice owing to situational adaptation – to different pedagogical approaches, curriculum time limitations, pupil groups, resources available and physical features of the technology and setting. Thus we can characterise 'expert practice' only in light of currently operating contextual constraints. Some practitioners have made major strides in structuring use of the technologies so as to represent and develop target concepts effectively for particular learners. Implications of the findings for design of technology-integrated activity are discussed in our papers in each domain.

Activities

During the course of the award, members of the research team have kept in contact with researchers and practitioners in the field through contributing to a wide range of meetings organised by national agencies, notably the British Educational Communications and Technology Agency (Becta), and the Qualifications and Curriculum Authority (QCA); and by participating in the annual meetings of the British, European and American Educational Research Associations.

Results of one analysis (of archetypical use of dynamic geometry in mathematics) were presented at the 2004 meeting of the *British Educational Research Association.* Further presentations of findings relating to all mathematics and science practices are scheduled for seven conferences during 2005 (see Annexe 8 for details).

Outputs

The full list in Annexe 8 indicates that publications are being prepared for both academic and professional audiences. For example, in relation to the first analysis to be completed (dynamic geometry in mathematics), two publications are in preparation for leading research journals, and two articles (one reporting the analysis of archetypical practice; the other making suggestions for developing it) have been already been accepted by the professional journal *Micromath*. Further articles are planned for appropriate journals of the other professional associations in the United Kingdom and United States. Publications following this broad pattern are in preparation for each of the other four practices.

The attached article on simulation has been submitted to the *International Journal of Science Education* and another paper on data logging aimed at practitioners will be submitted to *School Science Review.* An accessible review of classroom uses of ICT to support science teaching and learning was commissioned and published by *Nesta Futurelab*. A research review is being prepared for *Studies in Science Education.*

Selected reports will be disseminated via the Becta ICT Research Network. All publications will also be downloadable from our website (http://www.educ.cam.ac.uk/istl/pub.html).

Impacts

Outputs from the project are being circulated to appropriate academic and professional contacts. For example, the analysis of archetypical use of dynamic geometry was sent to members of the current working group of the QCA on *Mathematics and ICT,* which includes representatives from the professional associations in mathematics education, the mathematics inspectorate, the National Strategies, and the DfES (ICT in Schools division). It has become an influential point of reference for discussion of future plans for curriculum and assessment policy and pedagogical guidance.

Future research priorities

We intend to complete a full publication programme from this project, and, although not part of this proposal, to carry out further within- and *cross-practice analysis.* The project has yielded a rich dataset which can be exploited in several ways in future.

We also intend to synthesize our findings with those of other projects; notably Interactive Education (Sutherland, 2004) in which the focus has been on design initiatives aimed at developing practice, complementing our studies of practice currently regarded as exemplary.

We have already obtained ESRC funding for a new 30-month project on teacher mediation of subject learning with ICT, commencing in January 2005 (RES-000-23-0825). This builds on SET-IT through again involving 'expert' practitioners, this time as co-investigators. It employs digital video with the aim of producing DVDs for wide dissemination of replicable exemplars of successful practice, thus increasing the impact of SET-IT findings.

The findings have indicated a number of ways in which current professional practice could be strengthened; future work –in collaboration with practitioners and relevant national agencies– is envisaged to develop and disseminate enhanced approaches. Developing an appropriate synthesis of methods of design experimentation, lesson study and didactical engineering to support such development and dissemination will provide the basis of a future proposal to the ESRC.

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