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Eliciting situated expertise in ICT-integrated mathematics and science teaching

SUMMARY OF FINAL REPORT TO ESRC 2004

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SET-IT Project: Summary of Final Report

This research has identified, documented and analysed exemplary cases of a range of teaching practices which integrate use of ICT to support the learning of mathematics and science in secondary schools. This has enabled us to understand how practitioners adapt their expertise when new technologies are introduced into school settings. The practices chosen for investigation were: the use of (1) dynamic geometry, and (2) graph plotting, both in mathematics; and the use of (3) multimedia simulation, (4) interactive whiteboard (IWB), and (5) data capture and analysis, all in science.

Through a multi-stage research process, evidence gathered at each stage informed the decisions made at the next:

i. We solicited expert recommendations of school departments where exemplary practices might be found, then cross-checked the 52 nominations against public indices of quality, identifying 21 particularly promising departments.

ii. We conducted focus group interviews with these departments, in which teachers described what they saw as their most successful ICT-integrated teaching practices.

iii. We identified 5 types of teaching practice widely viewed as promoting pupil learning, and individual teachers who had been articulate in their pedagogical thinking about each practice, so assembling a structured portfolio of 19 teacher-practice cases.

iv. We documented each case, typically through observing two lessons involving different classes, on each occasion conducting post-lesson interviews with the teacher and with a group of pupils, using structured prompts to elicit their thinking about the practice.

v. We analysed the cases of each practice, individually then collectively, through qualitative coding of the transcripts of teacher interviews, supported and extended using observation records and transcripts of pupil interviews and earlier departmental interviews. We thereby established major pedagogical themes characterising each practice.

Our **key findings** are as follows:

(a) Teachers designed lessons around carefully controlled situations intended to focus attention on target issues, structured according to their assessments of the capacities of pupils to manipulate variables and interpret models or results appropriately. In graph plotting, for example, control of variables was typically built into task specifications for lower ability classes, whereas higher ability classes were presented with more open specifications, and prompted to control variables if necessary. In science, identifying learning demands and auditing pupils' knowledge enabled targetted recap which primed learners for more effective subsequent interaction with a simulation intended to challenge everyday beliefs and develop a more scientific model. In both dynamic geometry and science activity using the IWB, some teachers employed demonstrations only or limited pupils to manipulating pre-prepared figures or images.

However, the *mode of use* of each of the technologies varied across the cases and within lessons, incorporating: teacher-led demonstration, exposition and recap; individual/pair work, guided by worksheets and teacher interventions; interactive whole class teaching using projected visual aids as stimuli.

(b) Teachers used ICT to increase the ease, speed and accuracy with which routine tasks could be carried out, helping to focus attention on the key ideas, and allowing varied examples and possibilities to be considered. For example, through use of data logging for data collection and graph production, lesson time became available for discussion and interpretation of results. IWB software significantly facilitates preparation, organisation and presentation of multimedia resources, and instantaneous transition between them. Likewise, in mathematics, ICT was used for rapid and reliable production of varied graphs and figures.

(c) Teachers ensured that students appreciated ICT-mediated processes and products, sometimes through probing them directly, sometimes through relating them to analogues 'done by hand'. In mathematics, for example, 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 could be achieved by giving students experience of calculating and plotting a graph 'by hand'; or by using the tabulation or tracing facilities of a graph plotter to establish a similar pointwise perspective. Likewise, in science, technology use was integrated (and sequenced) in various ways with complementary practical work. For example, pupils' use of a simulation on mixing beams of different coloured light built on practical work with prisms earlier in the lesson; the teacher linked these activities by demonstrating light mixing using hand torches with filters.

(d) Teachers exploited the immediate feedback, ready modification, and dynamic visual presentation afforded by ICT in order to make concepts more salient and accessible to pupils. For example, the immediacy of ICT feedback was used to create a more interactive sense of the relation between the modification of an equation and change in its graph, further assisted by use of zooming and other rescaling operations to capture the graph in the screen window, and of dynamic editing of equations to structure the incrementing of coefficients. Likewise, in science, the annotation facility of the IWB was widely exploited, and data logging of student movement permitted features of movement to be monitored (and adjusted) through the immediate feedback provided by a dynamic graph display, providing an embodied referent for that graphic representation.

(e) Teachers treated curricular topics in ways which largely retained established formulations and organisation, although some teachers encouraged and were responsive to wider experimentation mediated by ICT. For example, one science teacher used a projected terminal velocity simulation to stimulate pupil questioning, scientific reasoning, collaborative hypothesis generation and testing, and synthesis. In graph plotting lessons where tasks were posed in relatively open terms (or where pupils breached them), the examples chosen and the questions posed by pupils sometimes led them and their teachers beyond familiar controlled examples. Likewise, where teachers expected pupils to construct dynamic geometric figures for themselves, and welcomed some unexpected software behaviours, they saw such experiences as providing opportunities for mathematisation. Nevertheless, the reported benefit of the technologies in facilitating an investigative approach was not always exploited in practice owing to contextual constraints – teachers' existing pedagogical approaches, curriculum time limitations, and restricted resource availability.

The project outcomes are being disseminated widely to both professional and academic audiences. The initial findings concerning mathematics practice are already influencing policy discussions in the current QCA-organised interagency working group on *Mathematics and ICT*.