

**The use of ICT to improve learning and attainment
through interactive teaching
(ITICT)**

A project in the Teaching and Learning Research Programme

Final report to ESRC – expanded version

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Background

The question of whether, and by how much, ICT impacts on learning and attainment has been posed frequently in recent years and has been investigated in large scale and small scale studies (Cox and Abbott, 2004). It appears that there is a small general improvement in attainment associated with high use of ICT, but this overall effect hides a wide variation in different circumstances (Becta, 2003). It is unclear under what conditions a more substantial improvement can be obtained, or quite why ICT makes a difference in particular circumstances. A number of potentially helpful features characteristic of ICT have been identified (Kennewell & Beauchamp, 2007), yet the 'ICT interference factor' (Birnbaum, 1990) may inhibit learning in many settings. There is substantial evidence concerning ICT's ability to motivate learners to engage in cognitive and, perhaps more importantly, metacognitive activity (Cox, 1997). This may be a potential source of learning gains in all subjects, but Cox & Webb (2004) emphasise that the effects of ICT on learning are dependent, among other factors, on teachers' subject knowledge, pedagogical beliefs and values, teaching approaches, confidence and organisation.

Many teachers are now incorporating ICT into their everyday practice, particularly in well-resourced schools with data projectors and interactive whiteboards (Kennewell & Beauchamp, 2003; Glover and Miller, 2001). However, this in itself does not lead to the sort of changes in pedagogy which may be needed to improve learning and attainment beyond what can be achieved with the best use of non-digital tools for teaching and learning (Beauchamp, 2006). Teachers' pedagogical content knowledge – the ways that they represent aspects of a subject – must develop to take account of ICT (Mishra and Koehler, 2006).

Interactivity as a construct seems to have a powerful role in representing what is effective in teaching, although there is no general agreement as to what constitutes interactive teaching (Moyles *et al*, 2003). Hargreaves *et al*. (2003) identify nine types of interactive teaching derived from teachers' descriptions, divided into 'surface' and 'deep' forms. The literature on pedagogy and learning, particularly that concerning mathematics, suggests that there is a continuum of interactivity from the 'lecture' style with no interaction between teacher and learners, through 'funnelling', probing questioning, uptake/focussing questioning through to collective reflection (Kennewell *et al*, 2008). Teaching at the higher (or deeper) end of this scale which is collective, reciprocal, supportive, cumulative and purposeful has been characterised as dialogic (Alexander, 2004), whilst Scott *et al* (2006) additionally represent the opposite end of the scale by the term 'authoritative'. We can characterise the scale in terms of the degree of contingency with which teachers and learners orchestrate the affordances and constraints of the setting in order to support the achievement of learning goals (Kennewell *et al*, 2008).

It might be expected that the interactivity which is characteristic of ICT (TTA, 1998) would assist interactive teaching, and the interactive whiteboard (IWB) should particularly helpful for teaching characterised as interactive. Indeed, in

2003 the Welsh Assembly Government invested in one IWB for every primary school and three for each secondary school in Wales. Since this time, there has been considerable funding in England, too, with several evaluation projects report mixed effects of large-scale provision of IWBs (Higgins et al, 2005; Moss et al, 2007; Somekh et al, 2007).

Teachers vary in their degree of confidence and competence with these technologies (Kennewell & Beauchamp, 2003). Despite the widespread uptake of government funded training for the use of ICT in subject teaching across the UK, most of teachers' professional learning concerning the use of ICT is gained through individual exploration of software and through sharing ideas with colleagues (Ofsted, 2004). In this situation, the development of an integrated 'pedagogical ICT capability' in relation to the IWB seems to follow a continuum in terms of technical and pedagogical skills (Beauchamp 2004). The analysis of how teachers use their pedagogical ICT capability has also been aided by the development of frameworks such as those of Squires & McDougall (1994), Kennewell (2001), Cox and Webb (2004). These approaches are based on orchestrating the affordances and constraints of ICT in relation to their learning objectives, the tasks set and pupils' abilities, and offer the most fine-grained methods for analysing the rich sets of data obtainable from the classroom and were consequently adopted and developed further by this project.

Objectives and main findings

Objective 1. To compare the learning outcomes of effective teaching in mathematics, science and languages using digital and non-digital tools.

This objective was addressed through a mixture of qualitative and quantitative methods involving pupil assessments and classroom observation. Although difficulties in the recruitment of good teachers who were not using ICT, and movement/maternity of teachers during the project, reduced the amount of data available, it has been possible to make comparisons in each subject and each Key Stage involved. **In general, no significant difference between using ICT and not using ICT for interactive teaching has been found, although there are some differences in attainment according to the level of interactivity in teaching which are smaller when ICT is used.**

Objective 2. To analyse and theorise the links between interactive teaching practices and improved learning outcomes when ICT is used in classroom settings.

This objective has been addressed qualitatively through teacher and pupil interviews, classroom observation and reflective dialogue with teachers and pupils. The relationships between interactivity of teaching and pupil learning have been explored in terms of the affordances and constraints of different features of the classroom including communication media, forms of interaction, nature of tasks set, and extent to which these are orchestrated by teachers and pupils in order to complete tasks and bring about learning. **There is widespread agreement between teachers and pupils concerning the need for pupils to participate actively and to influence the course of action, including whole-class teaching episodes, in order to improve learning. There is evidence that ICT is being used to assist in this approach, but the interactivity supported remains at a relatively low level while teachers gain skills and evaluate resources in ICT.**

Objective 3. To analyse changes in teachers' pedagogical practice as a result of designing interactive teaching strategies and engaging in reflective dialogue in relation to ICT tools for teaching and learning.

This objective has been addressed qualitatively through pre-and post-interviewing and by comparing observations of lessons in each phase of the project. **Whilst many teachers do not identify any changes in their pedagogical approach, some have decreased the amount of direct teaching, broadened the range of activities for pupils and increased the independence of pupils.** The effect has also been explored quantitatively by comparing attainment gains by similar classes taught by the same teacher in each phase. Although the results do not support generalisation beyond the teachers involved, this has indicated that **teachers who are very effective without ICT may not immediately enhance their teaching when they adopt ICT, and their performance can dip as they gain ICT skills and experiment with how ICT can best be integrated into their practice. Teachers already using ICT, however, tend to improve their**

effectiveness and can gain from reflecting on their practice, discussing ideas and sharing resources from colleagues.

4. To develop research capacity in Wales concerning learning, teaching and professional development.

This objective has been addressed through assembling a team which included experienced researchers and members who were new to funded research activity. Regular meetings, funded training and email discussions were used to develop thinking about suitable approaches and methods, in order that more staff would feel able to engage in research independently and to formulate/lead projects. **Members of the team have consistently responded positively to surveys concerning their professional learning in educational research, and several members have confidently taken on the management of new funded projects which employ the same model as ITICT for involving novice researchers from different institutions in Wales.**

Methods

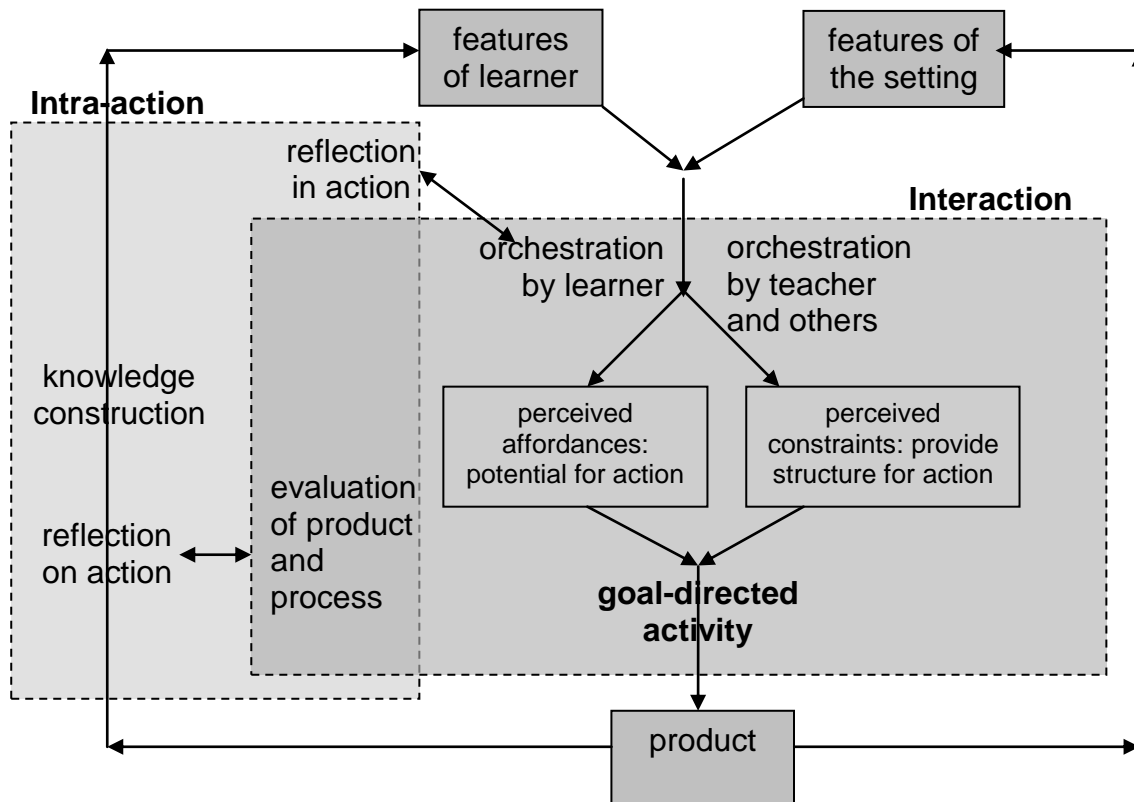
The project involved a total of 41 teachers from 21 primary and secondary schools, working in pairs to plan a six month period of teaching in one subject (mathematics, science or second language) with a particular class. In phase 1, one teacher worked with ICT and one worked without in this limited context. In phase 2, all teachers had ICT available as a resource, together with professional development opportunities to help them make best use of ICT in conjunction with other resources. Because of numerous cases of maternity leave, promotions etc, there were some unintended changes in teachers involved between phases.

Data was collected from initial teacher and pupil interviews, initial assessment tasks, classroom observation, video-stimulated reflective dialogue with teachers and with groups of pupils, and final interviews with teachers and pupils. A mixed-sex group of four pupils from each class were asked initially about their classroom and activities, focussing particularly on what they did in lessons, how they participated in joint/communal activity, and how they learned from this. They were also asked about their perceptions concerning differences when ICT is used.

After a classroom observation which was recorded by two cameras, one focussed on the front of the classroom and one capturing pupil activity, the teacher selected a particular section of the lesson to discuss with a member of the research team. The group of pupils were also asked about their perceptions of this episode, using the video as a prompt for recalling the activity. A second assessment, using the same test, was carried at the end of the phase of teaching.

Interview data was analysed using a grounded approach, with comparisons of emergent themes being made between ICT and non-ICT users, between subjects, and between key stages. Observation data was analysed using a framework for analysing teaching and learning in activity settings, with defined categories of factors and relationships against which classroom activities have been classified and compared (see Figure 1). Assessment data was used to compare gains in attainment between ICT and non-ICT groups using ANCOVA techniques with initial scores as covariate, and responses to conceptual questions are being analysed in depth to seek patterns of response within ICT and non-ICT groups.

Figure 1 Analysing teaching and learning in activity settings



In most of the 9 subject/KS cells in the research design (see table below) there were two pairs of classes, although data is incomplete for some pairs because of changes in staffing or anomalies in the teaching or assessment process.

	Science	Maths	Languages
KS1	1 pair	2 pairs	2 pairs (Welsh second language)
KS2	2 pairs	2 pairs	2 pairs (Welsh second language)
KS3	2 pairs*	2 pairs	2 pairs (Welsh 2L)

* Teaching through the medium of Welsh

Although the design did not have the characteristics of an intervention study, professional development was a key theme of the project and it was expected that teachers would change their beliefs and practices to some extent through the reflective aspect of the data collection, and through the project conferences – an initial one to induct teachers into the research and one between phases to allow teachers to share ideas with colleagues in other schools and Key Stages. Specific training was also provided for two teachers who were to use ICT in phase 2 but did not have IWB experience. The effects of this process was studied by means of final interviews and a post-project evaluation conference.

Results

A summary of the findings in relation to the research questions is given in the Objectives section above; this results section will therefore focus on expanding, in each strand of the project, some of the detailed results which underly our broad conclusions and explicating the warrant for the findings.

The project has a rich and extensive pool of quantitative and qualitative data. This report presents only the key aspects of findings to date. Work is continuing on micro-analysis of lessons to produce case studies of practice and on the analysis of different perspectives on interactive teaching and the influence of ICT drawn from interview data. Further publications will be produced to disseminate these findings.

Teachers' developing views of interactive teaching

The questions asked in the initial interviews were designed to elicit general responses, although the actual responses reflected the lack of a precise or standard language for describing pedagogical practice and clarification was sought where meanings were unclear. Teachers referred to the organisation of pupil activities in general, including whole-class, group and individual forms of activity and it was not possible to map teachers' thinking directly onto the interactivity scale which was designed to characterise whole-class teaching only. There is, however, potential for generating similar scales for group and individual forms of activity, and work is continuing on developing such scales which are grounded in our data, and using these scales as a tool for analysing practice and professional development.

Most of the teachers spoke clearly about the relationship between their role in generating interactivity and greater pupil responsibility for managing activities, generating ideas, reflecting on learning and assessing what they had achieved. This suggests that their thinking, at least, was focussed on the dialogic end of the scale.

Teachers' views were characterised in terms of their purposes, the participants, and the modes of communication. Factors influencing their interactivity, with a particular focus on ICT, were identified.

The purposes of interactions were broadly characterised as:

- instructional: those interactions initiated with the intention of developing specific aspects of another participant's knowledge;
- organisational: those interactions initiated with the intention of developing/maintaining social relationships and an effective learning environment generally.

Instructional interactions were either planned by the teacher, using their knowledge of the learners' characteristics; initiated by the teacher when they realise an intervention is needed to generate learning; initiated by a pupil who realises they can help one of their peers; or initiated by pupil who feels that they do not have the knowledge required for the task. Many of the teachers

highlighted the value of making mistakes explicit and discussing what changes should be made. ICT was seen by some as a means of encouraging learners to attempt an answer. Organisational interactions concerned task organisation and social management, with a common emphasis on group/pair work. Several teachers indicated that participation in activities by all learners was a pedagogic goal in itself, and perhaps also a prerequisite for effective learning. There was no indication of any difference in purpose when ICT was involved.

The participants in interactions could be teacher and pupil(s), pupil and pupil(s), pupil and resource. The key factor in higher levels of interactivity seemed to be the contingency of feedback on the pupil's response and the sustaining of interaction for as long as was necessary for learning. There was some expectation that pupils should initiate interactions with teachers, but teachers did not wait for pupils to ask them questions. They referred to observing pupil activity and listening to group discussion, intervening when an opportunity arose to advance learning. Teachers felt that group work encouraged pupils to initiate interactions, and tasks were often structured to ensure that these interactions took place. Several teachers gave pupils explicit peer-teaching roles:

Pupils were also expected to initiate interactions with resources, and there was some reference to ICT as a resource for pupils to control. ICT was also seen as an initiator of interactions, by providing a question (often chosen randomly so that the teacher could not plan what it would be) or a problem to be solved (such as matching or classifying images or words). The inability of pre-programmed resources to select the right level of challenge for the class was seen as a limitation. As well as initiating interactions, ICT was also seen as valuable in stimulating mental interactivity for the learners.

The modes of communication were broadly classified as:

- talk
- text (handwritten, printed, electronic)
- image (diagrams, pictures, video, other items looked at rather than handled)
- movement (including gesture, touch and handling materials other than writing/speaking aids,).

Speaking and listening were seen as important tools for interaction in all subjects. Whilst speaking and listening are key elements of the subject in the case of second language learning, whole class communication in the target language was not always interactive because pupils did not know the words they wanted to say, and the teaching language was sometimes used for talking about the structure of the target language.

Text was also seen as a valuable mode of interaction, but mostly in a brief and ephemeral form. Mini-whiteboards were sometimes provided for all pupils to write responses which could be shown to the teacher or to other pupil without the whole class being able to see; this was felt to foster risk-taking and mistake-making which was seen as necessary for effective

learning. More public texts were often produced in electronic form, particularly on the interactive whiteboard.

Images were seen as particularly valuable in initiating interactions, and the size, clarity and variety available using projected computer images have a large effect on engagement during whole class teaching. Animation and video were felt to provide surrogate experiences in a way that static images could not, particularly in science.

Communication through physical movement often has an organisational purpose, but sometimes is related to the matter being taught. The action known as 'drag and drop' on the interactive whiteboard, whereby a pupil touches the board and traces out a path to move an item on the board to a new position was usually used for matching and classifying tasks as alternative to speech or writing. The kinaesthetic experience at the board rarely represented the idea to be grasped. Images and movement were both used by some teachers to stimulate mental interactivity, and the IWB was seen as a possible aid to this.

Teachers varied in the extent to which they implemented interactive teaching, and their responses revealed a number of factors which influenced their decisions on interactivity. Most of these factors were common to all the subjects involved in the project:

- Teacher's role
- Learner's role
- Learners' knowledge and ability to learn
- Learning styles
- Learners' motivation and confidence
- Assessment
- Reflection and metacognition
- Curriculum
- Learners' gender
- Class and group organisation
- Type of task set for learners
- Resources available

It was clear that an interactive approach involved changes in role from traditional pedagogy in each subject, with the teacher being more of a manager or facilitator of interactions designed to bring about learning, and learners taking a pro-active role and engaging in actions traditionally associated with the teacher such as questioning, evaluating and explaining. Problem-solving was encouraged in all subjects, and making mistakes was generally viewed positively as an opportunity for reflection and pedagogical interaction.

There were differences, however, in the perception of potential for interactive teaching depending on the age and ability range, with some teachers being more interactive with older or more able learners (who are easier to manage), others with younger and less able (for whom there is less content to be covered and hence more time for two-way communication).

The influence of ICT was limited at the time of initial interviews. The value of tool software such as graph plotting and slide presentation software was recognised by some, but teachers felt they needed more time to understand how to exploit it fully. Software with pre-programmed teaching content was used selectively, and again the time needed to identify the most worthwhile aspects was at a premium.

Non-ICT tools and resources were also seen as valuable in supporting interactivity of all types. The use of mini-whiteboards for each learner - on which they could write brief ideas and quickly rub them off – was frequently described in all subjects. Books, however, were rarely considered and then only to compare unfavourably with ICT resources which were dynamic, interactive and could be shown simultaneously to the whole class.

The interviews carried out at the end of the project were analysed in terms of the changes in pedagogical beliefs and practice during the project, the influence of ICT on their practice, and the ways that the project had stimulated professional learning.

Several of the teachers did not acknowledge any change in their ideas or practice during the project, but most identified a greater integration of ICT into their practice as a result of reflection on experience, discussion with other teachers, and Internet searching. Those who did recognise a change often highlighted their emphasis on the value of mistakes – making mistakes explicit and developing a culture whereby pupils could make public mistakes with expectation of support and explanation rather than fear of ridicule. They had shifted more responsibility to pupils, listened to them more, made their actions contingent on what pupils did, and encouraged pupils to teach each other. They questioned pupils more deeply, set more open, activity-based tasks in groups, allowed more movement and prepared more differentiated activities to cater for pupils with additional needs either grouped together or with more able pupils.

For some, starting to use ICT had made little difference to teaching approaches, providing additional and replacement material such as images, video clips and quizzes to enhance existing practice. Some experienced users recognised that they were more selective with ICT, and some had changed their ways of working: for instance, letting pupils work on the IWB in small groups, and using the ICT room to enable pupils to find things out for themselves rather than presenting prepared material on the board. There was some feeling that ICT enabled pupils to take more responsibility and work independently, and that rapid feedback boosted confidence. There were suggestions that pupils with learning difficulties were stimulated and encouraged, and for one teacher, seeing what less confident learners could do with ICT had changed her perception of those pupils' ability. Teachers felt that ICT could not do everything, however, and needed to be supplemented with practical work in science and oral work in language teaching.

In reflecting on the project process, many teachers referred to the frustrations of ICT malfunctions, but felt in a position to take greater initiative in solving problems and developing their own skills. They valued the collaboration with other teachers, but placed most value on being able to watch themselves teach and discussing episodes with the researcher. They had become more open to ideas and more confident in developing their own with ICT. One teacher also recognised the value of pupils reflecting on a video of the learning.

Pupils' views

Pupils' recollections of their recent classroom activity focussed primarily on processes that they had participated in actively. More passive activity, involving watching or listening, was recalled if there had been particular enjoyment or excitement. 'Fun' activities such as games and quizzes were valued by all groups of pupils, and these were characterised by interaction with rapid feedback, competition, and unpredictability. Constructive activity, involving physical manipulation, drawing, or producing ICT products, was valued, and many pupils enjoyed performing in front of the class.

In response to general questions about how they liked to learn, different pupils expressed preferences for particular modes of communication including songs, conversations, drawing, manipulating equipment, physical movement, pictures, movies. Listening was not mentioned as a preference, however, and handwriting was clearly disliked by almost all those who commented on it, particularly if it involved copying material from the board or books. Other media were identified as valuable by some, including the traditional books for pupils and the whiteboard for the teacher, but there was more enthusiasm for newer items: the mini-whiteboard which was personal to each pupil yet easily shown to the teacher or a partner, the interactive whiteboard, which was easily seen by the whole class, and video or audio clips as long as they were under the pupils' control. Many pupils were clear that 'fun' was a factor which helped them to learn, rather than an entertaining distraction.

Pupils commented on the value of whole-class, small group, pair and individual modes of grouping, again with different preferences. Some pupils admitted to being nervous when answering questions or performing in front of the class, but were confident when working with their friends. Others recognised the value of working with less familiar peers, who might offer alternative ideas. The underlying idea, however, was the value of participation in activity and doing something themselves to help with constructing meaning.

A number of interpretations of learning emerged with suitable prompting, though younger pupils were often unaware of learning taking place. The most common perception of learning was as a process of memorisation, and there were different preferences for memorisation strategies, including visual, oral and written repetition. Mutual questioning of a partner was also identified as helpful, and a small number described a process that was reflective, rather than merely repetitive.

The effectiveness of different teaching approaches again varied between learners. The most commonly valued teacher activity was 'telling us things', though usually there was an implication that this was more than mere transmission of information and that the teacher was good at explaining and would 'go over things' as much as was needed to 'get in into their heads'. Question and answers was rarely mentioned without prompting, although when discussed it appeared that a style whereby pupils were never sure of who would be asked to answer was most effective in ensuring the engagement of all pupils. Other aspects of assessment, such as the teacher observing their work and intervening when they 'went wrong' were valued. Indeed, many pupils were very clear that they learned from their mistakes, and that their teachers valued discussion of pupils' mistakes as a means of helping the class to learn. Although pupils' comments tended to echo those of their teachers, and indeed teachers were seen to be making the value of reflecting on mistakes very explicit in the classroom, it did seem that pupils had internalised the principle and that this acted as an affordance for action in new learning situations. Few learners suggested that they might learn by asking questions, however. Some pupils recognised vicarious learning, although others indicated that if they were not active themselves, they were not fully engaged.

The influence of ICT took a number of forms. The interactive whiteboard was valued by most pupils, and even those whose teacher did not use one were aware of what they could do from experience in other classes. As well as the large, bright, clear display of prepared material, including authentic sound, they valued the rapid feedback and which interactive materials provided and the facility of changing their mind. They mostly enjoyed coming up to the front to do things themselves including games, writing tools, drawing tools, and programmed teaching material. Use of individual computers, particularly laptops, was also valued for group and individual work, with typing into the computer much preferred to handwriting by those who commented. The Internet was used independently in science for finding information and pictures, and in MFL for problem-solving using target language websites.

Classroom practice and participants' reflections upon it

Activity

Types of activity are different with ICT compared with non-ICT. Games are more common with ICT but have different characteristics from manual ones. Speed is a key feature of ICT, and is valuable where it generated rapid feedback on learning, but when time constraints are a feature of a game or challenge, the learner tends to prioritise speed over strategic thinking or accuracy. Scoring generates competition but often diverts attention from the learning intended to developing strategies for gaining a high score. ICT activities often lack a progressive structure, with tasks generated randomly.

ICT-based quizzes are used widely and are seen as fun by pupils and easy to manage by teachers – often with 'voting systems': dedicated hand-held

multichoice response devices for pupils which allow the frequencies of different responses to be displayed without identifying individuals. Even quite young pupils could manage such activities in groups without full teacher supervision. The rapid feedback without exposure to ridicule was valued and answers could be recorded for the teacher to analyse later. In some cases, the teacher's emphasis was purely on what was the right answer, but other teachers used the results formatively and probed particular pupils concerning reasons for their correct or incorrect answers. This effect was also achieved quite easily in non-ICT classes using mini-whiteboards, however.

The speed and repetition features of ICT are also exploited when learners were able to see a rapid succession of cases of a particular phenomenon, such as angle relationships, which can help with inductive concept generation. The range, capacity and linking features of ICT afford systematic searching for information, providing an exploratory experience in contrast to books which tend to give an answer very easily. However, pupils preferred traditional practical work to simulations in science because they enjoy the physical manipulation, recognise that it is what 'real' scientists do, and are cognitively engaged by the relative unpredictability of the setting.

Teaching and learning

Teachers use a variety of levels of pedagogical interactivity in each lesson, but predominantly work at the lower levels. This is particularly the case in language teaching, where use of the target language is paramount and deeper reflective interaction is more difficult. Interaction in target language reduces with ICT: teachers ask fewer questions and there is more reading and writing of key words and phrases because these actions are the ones supported by the affordances of ICT currently perceived by teachers. However, this was overcome to some extent by using ICT displays to support oral activities by pupils. The sound feature of ICT was only rarely used.

Teachers used a variety of pupil activity groupings: whole-class, group, pair, individual. The level (not rate) of interactivity was greater when the teacher was directly involved to prompt at a conceptual level, to question pupils about reasons, and to answer pupils' questions. Discussion with peers – often in short segments of a whole-class lesson phase - seemed to be valuable in allowing pupils to articulate tentative thoughts, and much more so if ideas were subsequently shared/challenged more widely with teacher orchestration. When there was no direct teacher intervention in groupwork, the depth of interactivity depended very much on the richness of the task and the culture of collaboration in the classroom.

Different media were used to support interaction, including mini-whiteboards, cards with words/pictures, and ICT devices. ICT facilitated more independent investigation but in itself did not seem to generate deeper interactivity; indeed the inequality in pairs/groups in which only one member could operate the mouse/pen at a time tended to inhibit constructive interaction unless pupils were taught to take specific roles in collaborative tasks with ICT and to take turns in carrying these out. Teacher intervention during individual and group

work was less frequent and less sustained with ICT than with manual/oral tasks; as a result, these sometimes become more focused on completing the task than on the intended learning. When the teacher did intervene with ICT tasks, it was sometimes because of an ICT-related difficulty.

Most of the teachers who had ICT available pursued familiar pedagogical practices and utilised ICT where this supported them, but there were other cases where the arrival of new technology stimulated change because it enabled new forms of activity and facilitated different types of task. Teachers were sometimes driven by the constraints of the pre-programmed software that they were provided with, but most selected from this carefully in order to support the teaching approach they felt was most appropriate. Some chose flexible software and specified the constraints for action within the task set. Pupils often subverted the task, even with highly constrained software, when the technology afforded alternative actions with more motivating goals.

Less confident learners often missed out during whole-class teaching with or without ICT because they appeared to be engaged and their difficulties were obscured, but working in pairs or individually orally and with ICT enabled them to participate more. Differentiation of activity was often achieved effectively though use of an ICT room with sufficient computers for individual use.

Effects associated with IWBs

Teachers had a variety of systems for organising pupils at the board in front of the whole class – by systematically taking turns, by nominating a representative of group, or by nominating a representative of an idea to demonstrate. The turn-taking procedure was not used to ensure all pupils participated for the sake of it, but to maintain engagement and, in primary schools to provide a model for ensuring participation when groups of pupils took responsibility for activity at the board.

Pupils working at the front of the class usually had an effect on the rest of the class which was different from if the teacher was doing the work: they generated empathy from other pupils, and the unpredictability of the outcome on the board maintained the attention/interest/engagement/participation from class. Pupils who worked on the IWB were given advice spontaneously by other class members and there was no sense that a pupil would be ridiculed if s/he got something wrong. Class advice on actions and, more rarely, discussion of reasons, was usually orchestrated by the teacher.

The IWB gave something more visual/dynamic to look at, so that pupils spent longer looking at the board than at the teacher. Presentations using the IWB seemed able to engage young learners for longer than traditional pictured flash cards, and there tended to be a wider variety of approach. Few teachers used the full features of the IWB – most use drag-and-drop or just projection – but even these limited functions have the potential for generating classroom discussion and were often used in this way.

The ordinary whiteboard or flipchart was often used as well or instead of the IWB even when the IWB was available, and was often equally/more suited to the teacher's purpose. The ordinary WB was used both for display of material which needed continual reference during the lesson and, in secondary maths, for ephemeral notes/diagrams which referred to a particular display on the IWB. Teachers rarely used the annotation facility of IWB software to build representations of knowledge with the class.

The communal nature of the IWB, combined with the culture of valuing mistakes for their learning potential, may have facilitated the exposure of pupils' misconceptions. The potential to generate and resolve cognitive conflict was less often exploited, however, and most pupils were keen to learn 'the right way to do it' so that they did not make the same mistake again, rather than gaining an understanding which would improve their work more generally. The IWB was able to give better support for reflection than manual tools – particularly sharing ideas with the whole class (mainly in the form of Powerpoint presentations), displaying pupils' work and reviewing what was done on the board earlier in the lesson. There was little evidence of this being used to support reflection at deeper levels such as abstraction and generalisation.

The 'technical interactivity' of the IWB was used to support pedagogical interactivity, but mainly in that the projected images provided something to discuss or ask questions about. Whole-class interaction which influenced the course of activity on the board was not observed widely. In maths, there was often a focus on what is presented as an outcome on the board rather than the process of doing maths.

Effects associated with ICT in general

Laptop/desktop PCs were often used for practice of low-order skills and techniques which had been introduced through activity around the IWB, but were sometimes used for exploratory activities by pairs of pupils. Generally, pupils tended to focus on achieving the task outcome regardless of method, and ICT sometimes provided alternative ways of achieving the product without engaging with the intended ideas. Individual ICT activities often allowed pupils to obtain the answer easily with no need to think, or they were able to get the right answer by trial and error with no understanding. This was sometimes counteracted by teacher management of whole-class activity at the IWB, however.

Pupils with additional learning needs, particularly whose first language is not English or Welsh, seemed to gain from clearer visual material. They appeared to be more engaged in whole class teaching when the IWB was used, but this may only have been at a superficial level. When using appropriate software in small groups, however, they seemed more able to operate independently of the teacher and support staff, and could achieve learning beyond what was expected using traditional media.

Frequent cases of the 'ICT interference factor' were reported. This was mainly due to technical problems rather than lack of ICT skills – indeed, teacher and pupils together could often overcome problems experienced. In some cases, breakdowns and slow operation disrupted the flow of activity so as to counteract any advantage that ICT might have conferred.

Impact on learning and attainment

The main purpose of the quantitative pre- and post-assessment data is to help with analysis at a 'local' (case-study) level rather than 'global' level across the project. A large number of factors affect the learning and its measurement – including the nature of the school, the classes involved, the teachers, the schemes of work, and the resources available – and these need to be considered case by case. In each combination of subject and Key Stage, a more detailed analysis of the differences in classroom activity across the teachers involved is continuing and the assessment responses will be examined at a fine level of detail in order to help identify the learning achieved under the conditions pertaining during each phase of the project.

Whilst no generalisation from global analysis of quantitative data is possible in this research design, it has been possible to carry out a number of analyses of post-test attainment for particular sets of teachers, using pre-test as covariate, and it is reasonable to consider what patterns have emerged to date in looking across the analysis of particular comparisons, and what hypotheses for future investigation might be generated from these instances.

The overall pattern was of 'no significant difference' in Phase 1 between classes taught using ICT and those not taught using ICT. This confirmed the indications from the qualitative data that, despite the greater attention and interest that might be generated by ICT, teachers were not yet able to convert this in to significant improvements in learning. Indeed, there was a general trend for the non-ICT teacher to achieve better results, and when the qualitative data was examined for possible explanations for this, it emerged that, in most cases, the greater proportion of high-level interactivity was demonstrated by the non-ICT using teacher.

This produced a new hypothesis, for which there is already strong evidence from various sets of qualitative data, that the level of interactivity of teaching is a more important factor for successful learning than whether ICT is used or not. Using a combination of data across classes, with 'level of interactivity' as fixed factor in the analysis of covariance, it was found that in all cases where there was a teacher rated as using a substantial amount of higher level interactivity, that teacher achieved a higher gain in attainment during Phase 1 than colleagues using less higher level interactivity – in some cases, significantly so.

However, this differential in attainment gains was not generally maintained in Phase 2. Using a combination of Phase 1 and Phase 2 data for the same teacher and Phase as the fixed factor in the analysis of covariance, it was found that in some cases, the non-ICT using teacher who had achieved highly

during Phase 1 appeared to be less effective when using ICT in Phase 2; this could reflect a temporary dip in effectiveness whilst gaining expertise in using new technology. Additionally, there was evidence that some ICT-using teachers in Phase 1 had become more effective in using ICT to support interactive teaching. This could reflect the professional development in pedagogy with ICT gained during Phase 1.

Developing research capacity

New methods and tools

The framework for analysing teaching and learning in activity settings (ATLAS see Figure 1) is being used by all project researchers for the detailed analysis of the relationship between activity and learning in lessons. This innovative approach will lead to a number of case studies (see Kennewell et al, 2008 for an example) to be included in the proposed book in the TLRP *Improving Learning* series. A comprehensive taxonomy of features of ICT which support action in the classroom has been developed (see Kennewell & Beauchamp, 2007).

The use of VSRD with teachers proved to be a valuable method of professional development for those involved, and a further project has been funded by Becta to explore the potential of digital VSRD in staff development and produce guidance for teachers. The VSRD process involving pupils (see Tanner & Jones, 2007) has also been used effectively by project researchers and an adapted process, where pupils choose the lesson episodes to discuss, has been used successfully in other work by one of the team (Morgan, 2007).

Professional development of research staff

Research management expertise has been gained by experienced members of the team who have had responsibility for aspects of the project and regular contact with TLRP. Many members of the team were new to funded research, and all have gained considerably in knowledge and skills through working alongside experienced colleagues and engaging reflective dialogue with them following lesson observations and in project team meetings. Experience in using a virtual research environment has also been gained.

Several members of the team have been trained in using Nvivo software to aid qualitative analysis, and have disseminated this to other colleagues. The research assistant has developed substantial expertise with this software. SPSS expertise has also been disseminated during collaborative analysis of quantitative data.

Overall conclusions and implications for developing policy and practice

The detailed study carried out into how good teachers teach with and without ICT has provided considerable insight into the reasons why ICT has had relatively little impact on attainment and how its contribution might be increased. Whilst the use of ICT in whole-class teaching has stimulated

greater pupil motivation and attention, the relatively superficial improvements in clarity of information provided to pupils and in pupil involvement in activity at the front of the class, may be insufficient to overcome the disadvantages of ICT such as its unreliability and the inflexibility of much packaged curriculum software.

It is the depth of interactivity which is more important in stimulating learning. Most teachers adopting ICT use it for relatively authoritative teaching approaches, and it seems that they should try to identify how it can help them achieve a more dialogic approach to whole-class teaching. More research and development is needed concerning how ICT can be used to support deeper interactivity in groupwork (see, for example, Mercer, 1996) and more dialogic interactivity when used by individual students (Plowman, 2005).

There are three main ways in which interactive teaching is currently being supported by ICT. ICT can be used as:

1. The **object** of interaction (i.e. resources to interact *about* – when ICT provides a collective focus of reference such as a video clip or sample of pupil's writing).
2. A **participant** in interaction (i.e. a partner to interact *with* – when ICT sets tasks and provides immediate feedback such as a game, quiz or simulation).
3. A **tool** for interaction (i.e. a medium to interact *through* – ICT assists action in pursuit of goals, for example collectively developing a concept map of photosynthesis or individually constructing a sentence in the target language for interpretation, discussion and development by a partner).

It is the last of these that may best exploit the potential of ICT as a medium for dialogic teaching. Much can be achieved with 'traditional' resources: a large piece of paper and a supply of coloured pens provides potential for a group to collaborate on a task that is currently hard to achieve using an IWB, and a set of mini-whiteboards is a lot cheaper and can be easier to use ad hoc to gauge the range of ideas from a class than an electronic voting system. However, new technologies that can not only mimic but extend the affordances of traditional media are continually emerging and reducing in cost.

Teachers need to become attuned to the affordances of ICT's features so that they can orchestrate these contingently in support of task goals and learning goals; this takes time outside the classroom, opportunities to discuss with colleagues, and a willingness to experiment in the classroom. They need access to a substantial repository of flexible resources that they can draw on for particular purposes and adapt to meet the needs of their learners. Learners, too, need to have a high level of ICT capability in order to orchestrate the features of more flexible technology and teachers should aim to provide them with worthwhile tasks rather than merely expecting them to press buttons and drag objects across the screen in response to unchallenging questions.

Activities

In addition to the internal project conference (see Methods section), the project has been well represented at TLRP conferences in 2004-2007 inclusive, and has presented in 2005 and 2006.

The Principal Investigator has given research seminars at King's College London, ITTE Research Conference (Cambridge), Trinity College Carmarthen and the University of London Institute of Education. He chairs the IWB Pedagogy Research Group involving all funded research projects in the field.

Outputs

The principal outputs from the project are:

Kennewell, S. & Beauchamp, G. (2007) The features of interactive whiteboards and their influence on learning, *Learning, Media and Technology* 32(3), 227-241

Tanner, H. & Jones, S. (2007) Using Video-Stimulated Reflective Dialogue to learn from children about their learning with and without ICT Technology, *Pedagogy and Education*, 16(3), 321–335

Kennewell, S., Tanner, H., Jones, S. & Beauchamp, G. (2008) Analysing the use of interactive technology to implement interactive teaching, *Journal of Computer Assisted Learning*, 24(1), 61-73.

Other publications have been submitted to TLRP's D-space and ESRC Society Today.

In addition, conference papers have been presented at BERA (Manchester, 2004; Glamorgan, 2005; Coventry, 2006), MERGA (Melbourne, 2005), AARE (Adelaide, 2006), IFIP WG3.3 (Budapest, 2007) and IFIP WG3.5 (Prague, 2008).

Future research priorities

The findings of this project suggest that it will be fruitful to investigate the influence on teachers' practice and on pupils' learning of professional development in interactive/dialogic teaching in which the use ICT is explicitly incorporated into the training. This could be explored in England as well as Wales, to investigate the effect of education policy differences.

References

Beauchamp, G. (2005). Teacher use of the interactive whiteboard (IWB) in primary schools – towards an effective transition framework. *Technology, Pedagogy and Education*. 13(3), 327-348

Beauchamp, G. (2006) New technologies and 'new teaching': a process of evolution? In *Changing Teaching and Learning in the Primary School* (ed. R. Webb) Buckingham: Open University Press

Becta (2003). *Primary Schools – ICT and Standards. An Analysis of National Data from Ofsted and QCA*. Coventry: Becta.

Birnbaum, I. (1990). The assessment of IT capability. *Journal of Computer Assisted Learning*, 6, 88-97.

Cox, M.J. (1997). *The Effects of Information Technology on Students' Motivation*. Coventry: Council for Educational Technology.

Cox, M.J. and Abbott, C. (Eds) (2004). *A review of the research literature relating to ICT and attainment*. Coventry: Becta/London: DfES.

Cox, M.J. and Webb, M. (Eds) (2004). *A review of the research literature relating to ICT and pedagogy*. Coventry: Becta/London: DfES.

Glover, D. and Miller, D. (2001). Running with technology: the pedagogic impact of the large-scale introduction of interactive whiteboards in one secondary school. *Journal of Information Technology for Teacher Education*, 10(3), 257-278.

Hargreaves, L., Moyles, J., Merry, R., Paterson, F., Pell, Anthony, A. and Esarte-Sarries, V. (2003). How do primary school teachers define and implement 'interactive teaching' in the National Literacy Strategy in England?. *Research Papers in Education*, 18(3), 217-236.

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. (2001). Using affordances and constraints to evaluate the use of information and communications technology in teaching and learning. *Journal of Information Technology for Teacher Education*, 10(1&2), 101-116.

Kennewell, S. and Beauchamp, G. (2003). The influence of a technology-rich classroom environment on elementary teachers' pedagogy and children's learning, in *Young Children and Learning Technologies*, (eds. J Wright, A McDougall, J Murnane and J Lowe). Sydney: Australian Computer Society, 65-70.

Kennewell, S. & Beauchamp, G. (2007) The features of interactive whiteboards and their influence on learning, *Learning, Media and Technology* 32(3), 227-241

Kennewell, S., Tanner, H., Jones, S. & Beauchamp, G. (2008) Analysing the use of interactive technology to implement interactive teaching, *Journal of Computer Assisted Learning*, 24(1), 61-73.

Somekh, B. and 13 others (2007) *Evaluation of the Primary Schools Whiteboard Expansion Project: Report to the Department for Education and Skills* Manchester, MMU

Mishra, P. & Koehler, M (2006) Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge *Teachers College Record*, 108 (6), 1017–1054

Morgan, A. (2007) Using video-stimulated recall to understand young children's perceptions of learning in classroom settings *European Early Childhood Education Research Journal*, 15(2), 213 - 226

Moss, G., Jewitt, C., Levañiç, R., Armstrong, V., Cardini A. and 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 816*, London: DfES.

Moyles, J., Hargreaves, L., Merry, R., Paterson, F. and Esartes-Sarries, V. (2003). *Interactive teaching in the primary school: Digging deeper into meaning*. Maidenhead, Open University Press.

OFSTED (2004). *ICT in Schools: The Impact of Government Initiatives Five Years on*. London: Ofsted. Available online at <http://www.ofsted.gov.uk/publications/index.cfm?fuseaction=pubs.displayfile&id=3652&type=pdf>

Scott, P., Mortimer, E. & Aguiar, O. (2006) The tension between authoritative and dialogic discourse: A fundamental characteristic of meaning making interactions in high school science lessons, *Science Education*, 90, 605-631.

Squires, D. and McDougall, A. (1994). Software Evaluation: a situated approach, *Journal of Computer Assisted Learning*, 12, 146-161.

Tanner, H. & Jones, S. (2007) Using Video-Stimulated Reflective Dialogue to learn from children about their learning with and without ICT Technology, *Pedagogy and Education*, 16(3), 321–335

Teacher Training Agency (TTA) (1998). *The Use of ICT in Subject Teaching. Lottery funded training. Expected Outcomes for teachers in England, Northern Ireland and Wales*. London, TTA.