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The influence of ICT on the interactivity of teaching

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Abstract There has been much concern with the ideas of interactive and dialogic teaching during recent years in the UK, ideas which have emerged from international comparisons. This paper concerns a research project in Wales which sought to explore how the interactive features of information and communication technology (ICT) support interactivity in teaching. The project found that much use of ICT by good teachers was at a relatively superficial level of interaction, yet when teachers used a deeper, more dialogic, level of interactivity in teaching, they achieved improvements in learning whether they used ICT or not. The potential of ICT to support more dialogic teaching was not being fully exploited. The paper reports the findings of the classroom observation dimension of the project, and examines the implications for pedagogical practices and the development/dissemination of ICT resources which can support more dialogic interactivity.

Keywords Interactive teaching · Dialogic teaching · Classroom observation · Reflective dialogue

1 Background

1.1 ICT and learning

The question of how Information and Communication Technology (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

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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 et al. 2008), 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 motivation may be a potential source of learning gains in all subjects, but Cox and Webb (2004) emphasise that the effects of ICT on learning are moderated by teachers' subject knowledge, pedagogical beliefs and values, teaching approaches, confidence and organisation.

1.2 Teachers' use of ICT

Many teachers are now incorporating ICT into their everyday practice, particularly in well-resourced schools with data projectors and interactive whiteboards (Glover and Miller 2001; Kennewell and Beauchamp 2003). 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). The speed and extent of this development can vary between teachers depending on their degree of confidence and competence with these technologies (Kennewell and Beauchamp 2003).

1.3 Interactive teaching

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). It is used most in connection with whole-class modes of teaching. The literature on pedagogy and learning, particularly that concerning mathematics, suggests that forms of interactivity can be ordered using a scale of learner influence over the course of activity, from the 'lecture' style with no interaction between teacher and learners, 'funnelling' questions, probing questions, uptake/focussing questions up to collective reflection (Kennewell et al. 2008). At the higher end of this scale, teaching which is collective, reciprocal, supportive, sustained, cumulative and purposeful has been represented by the term '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).

1.4 Interactive technology

It might be expected that the interactivity which is characteristic of ICT (DfES 1998) would assist interactive teaching, and the interactive whiteboard (IWB) should be

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. Similarly, there has been considerable funding for IWBs in England. However, several evaluation projects report mixed effects of large-scale provision of IWBs (Higgins et al. 2005; Moss et al. 2007; Somekh et al. 2007).

2 Outline of project

The Interactive Teaching and ICT project, funded by the UK government's Economic and Social Research Council within its Teaching and Learning Research Programme (see http://www.tlrp.org) ran from April 2005 to June 2007. The project involved a total of 41 teachers from 21 primary and secondary schools, working in pairs to plan two phases of teaching lasting 6 months in one subject (mathematics, science or language) with a particular class spread over a 2 year period. Teachers were selected in consultation with headteachers of the schools and were identified as effective classroom practitioners. This approach enabled the project to include teachers with a variety of experience as well as attempting to exclude possible variations introduced by less effective pedagogy and practice. Even at the start of the project in April 2005, most good teachers were already using ICT quite extensively.

In phase 1, one teacher in each pair worked with ICT and one worked without ICT in the selected subject. The teacher using ICT was under no pressure to use ICT unless it was justified by their pedagogic reasoning—although in reality most made extensive use of ICT resources and facilities. In phase 2, all teachers had ICT available as a resource, together with prior professional development opportunities to help them make best use of ICT in conjunction with other resources. Teachers using ICT worked with the resources that were available to them; all had an IWB.

A mixed methods approach was adopted for the data collection and analysis. Prior to the project, data was collected from teacher and pupil interviews and age and subject-specific initial assessment tasks were undertaken to provide baseline data on pupil attainment. During each phase, pairs of researchers observed two lessons by each teacher. In every classroom observation, two cameras were also used to record the lesson: one focussed on the front of the classroom and one captured pupil activity. After each lesson the teacher selected a particular section of the lesson to form the basis for video-stimulated reflective dialogue (VSRD) with a member of the research team. In addition, in some cases pupils were also asked about their perceptions of this episode, using the video as a prompt for recalling the activity (see Tanner and Jones 2007). A second assessment, using the same test, was carried out at the end of the phase of teaching. At the end of the project, researchers conducted final interviews with teachers.

Interview data were analysed using a grounded approach, with comparisons of emergent themes being made between ICT and non-ICT users, between subjects, and between phases of schooling. Observation and VSRD data were 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 (Kennewell et al. 2008). Assessment data was used to compare gains in attainment between ICT and non-ICT groups using ANCOVA techniques

with initial scores as covariate. This produced results showing no significant difference in the key comparisons between ICT and non-ICT settings, but an overall trend for the more dialogic teachers to achieve higher gains in attainment (Kennewell et al. 2007).

This paper will focus on the general results from classroom observations and subsequent reflective dialogues. Other publications reporting on the analysis of teacher and pupil interview data, and on the effects of ICT and interactive teaching on learning in each subject, are in preparation.

3 Features of classroom practice

As may be expected with a sample of many teachers from different schools, a variety of classroom practice was observed. Although the teachers varied widely in their training and length of experience, the fact that all the teachers had been chosen as effective practitioners with a good level of support from the school reduced the impact of these variables. The main variables involved in the research design were:

- The age of the children being taught;
- The subject content matter and the degree of specialism of the teacher—in secondary schools all teachers would be specialist in their subject, while in primary schools this was rarely the case;
- And, most importantly, the use or non-use of ICT.

These will be referred to in the analysis below where appropriate.

3.1 Activity

ICT provided a number of features, both intrinsic and constructed, which afford and constrain actions in the classroom (Kennewell and Beauchamp 2007). The speed and repetition features of ICT were exploited when learners were able to see a rapid succession of cases of a particular phenomenon, which could help with inductive concept generation. This was seen, for instance, when pupils learning to construct reflected images in mathematics were able to move the corners of a shape around and observe the effect on the reflected image, while the teacher focussed their attention on which aspects of the configuration were invariant. This helped them with the manual construction of reflections.

The range, capacity and linking features of ICT afforded systematic searching for information, providing an exploratory experience-in contrast to books which tended to give an answer very easily. However, the lack of authenticity of ICT in some science work, compared to traditional practical work, meant that pupils generally preferred to explore using physical manipulation. They also recognised that it is what 'real' scientists do, and were cognitively engaged by the relative unpredictability of the setting.

> ... when you're watching the whiteboard, because you know it's always going to work, you're not really testing things but when *we're* doing it you don't know whether if it's going to be right or wrong so you're testing it. (10-year-old pupil about science lessons)

Games were more common with ICT, and had different characteristics from manual ones. Speed was valuable where it generated rapid feedback on learning, but when time constraints were a feature of a game or challenge, the learner tended to prioritise speed over strategic thinking or accuracy. Scoring generated competition but often diverted attention from the intended learning towards developing strategies for gaining a high score (see, for instance, the case study described in Kennewell et al. 2008). ICT activities not moderated by the teacher often lacked the progressive structure needed to extend pupils' understanding, particularly when tasks were generated randomly by the software.

ICT-based quizzes were used widely and were 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 at the IWB without full teacher supervision, although these activities were also used as a whole class activity, particularly in the final review section of the lesson. The rapid feedback without exposure to ridicule was valued by pupils. In some cases, the teacher's emphasis was purely on what was the right answer, but other teachers used the results formatively with the whole class and probed particular pupils concerning reasons for their correct or incorrect answers. However, this effect was also achieved quite easily in non-ICT classes using mini-whiteboards—small dry-wipe boards provided for each pupil to write their answer to a question and hold it up so that the teacher could see but not their classmates.

3.2 Teaching and learning

Teachers used a variety of levels of pedagogical interactivity in each lesson, but predominantly worked at the lower, more authoritative levels. This was particularly the case in second language teaching, where use of the target language was considered to be paramount, and deeper, reflective interaction was difficult for the pupils with limited skills in the target language. Interaction in the target language reduced with ICT—teachers asked fewer questions and there was more reading and writing of key words and phrases because these actions were the ones supported by the affordances of ICT currently perceived by teachers. However, this was counterbalanced to some extent by the advantages of using presentation software to support pupils' oral communication to the whole class in the target language; this seemed to give them a clearer focus for their work and more confidence in the target language. Surprisingly, the sound feature of ICT was only rarely used.

Teachers used a variety of pupil activity groupings—whole-class, group, pair, individual. The depth 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 was seen as valuable, and much more so if ideas were subsequently shared/challenged more widely with teacher orchestration. Without direct teacher intervention, the depth of interactivity, both with and without ICT, 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 and/or 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 was able to operate the mouse/pen at a time could inhibit constructive interaction unless pupils were educated 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, the pupils sometimes became more focussed 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 rather than for pedagogical reasons.

There was, however, a mutual influence between the use of technology and pedagogical practice depending on the teacher's pedagogical knowledge and beliefs. Most teachers pursued familiar pedagogical practices which they felt to be effective, and utilised ICT where they perceived its affordances for their intended actions, such as presenting information more clearly or in animated format, or enabling pupils to answer questions at the front of the class without writing on the board. The IWB was commonly used for matching and classifying tasks—for instance, pupils dragging a word in the target language onto an appropriate picture; or dragging a picture of an animal into a column headed by the class (mammal, reptile, etc) and explaining what features of the animal had led to their decision. But there were other cases where the arrival of new technology had stimulated change because it enabled new forms of activity and facilitated different types of task, such as moving a shape around on the screen and observing how its reflected image moved.

Having made the decision to use ICT, some teachers seemed to be driven by the constraints of the pre-programmed software that was available to them, but most selected from the available resources carefully to support the teaching approach that they felt was most appropriate. Some teachers chose flexible software and specified the constraints for action within the task set. Pupils often subverted the task, however, even with inflexible software. This tended to occur when the technology afforded alternative actions with more motivating goals, or when a solution to a problem could be obtained by trial and error rather than using a formal method or principle.

Less confident learners were sometimes reluctant to participate during whole-class teaching with or without ICT, although this was sometimes hard for teachers to identify as the pupils appeared to be engaged at a surface level and their difficulties were obscured. However, when working orally in pairs or individually, 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 or when learners were able to work in mixed ability pairs with laptops in the classroom.

3.3 Effects associated with Interactive whiteboards

Teachers had a variety of systems for organising pupils at the IWB in front of the whole class—turn-taking, representing a group, and representing an idea. When turn-taking was used, it was not merely to ensure that all pupils participated. Pupils were selected carefully for particular tasks in order to maintain engagement and, in primary schools, to provide a model for ensuring participation when groups of pupils subsequently took responsibility for activity at the board. It also provided another

opportunity for effective differentiation, as teachers were able to select learners who were able to succeed at tasks with some help from teachers or their peers.

Indeed, when pupils worked at the front of the class, this had a different effect on the rest of the class from when the teacher was doing the work: empathy from other pupils and the unpredictability of outcome on the board maintained engagement and participation from the class. Pupils who worked on the IWB were given advice—either spontaneously by other class members or with prompting from the teacher—and there was no sense that a pupil would be ridiculed if s/he got something wrong. The teacher also prompted discussion of reasons for actions at the board on many occasions.

The IWB also gave something more visual/dynamic to look at, so that pupils spent longer looking at the board rather than the teacher. Presentations using the IWB engaged young learners for longer than traditional picture cards, and there tended to be more variety of approach. Few teachers used the full features of the IWB—most used drag-and-drop or just projection, typical of the lower end of Beauchamp's (2004) transition framework—but the provisional nature of such actions afford classroom discussion and were sometimes used in this way.

The dry-wipe board or flipchart was often used as well or instead of the IWB even when the IWB was available, and was often equally or more suited to the teacher's purpose. The dry-wipe board was used both for display of material which needed continual reference during the lesson and, particularly in secondary mathematics, for ephemeral notes or 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 which would be representative of Beauchamp's (2004) 'synergistic' user.

The 'technical interactivity' of the IWB (Smith et al. 2005) was used to support pedagogical interactivity, but mainly in that the projected images provide something to discuss or ask questions about. The discussion of images and movies was particularly common in science work, and ICT features such as video-editing tools or the spotlight/magnifying tools on the IWB were used by the teacher to focus pupils' attention on particular aspects of what they could see. This was mostly pre-planned, and whole-class interaction which influenced the course of activity on the board was not observed widely.

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. Many pupils were encouraged to articulate their thinking about key ideas and evaluate the viability of alternative perspectives. For example:

> Pupil 1 When the first couple of pupils said it I thought no, that's not right, but then after more pupils said it I'm thinking, hang on now, I used to think this but now they've made me confused.
>
> Pupil 2 It does sway you a bit, doesn't it.
>
> Pupil 3 That actually got me thinking, why are they thinking that?
>
> Interviewer So what do you do then?
>
> Pupil 1 Well, I'd really check it through in my head and then after I did that I thought no, *they* are wrong...
>
> (11–12 year old pupils in mathematics)

The potential to generate and resolve cognitive conflict was not always 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. Teachers felt that the IWB was able to give better support for reflection than manual tools—particularly through 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.

3.4 Additional effects associated with ICT

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 also used for exploratory activities by pairs of pupils, such as science simulations or using graphing software to explore properties of linear functions. 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. This was, however, counteracted by teacher management of whole-class activity at the IWB (see Kennewell et al. 2008).

Pupils with additional learning needs, particularly those whose first language is not English or Welsh, seemed to gain from clearer visual material. They appeared to be more engaged during whole class teaching using the IWB, but this may only have been at a superficial level. When using appropriate software in small groups 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, however. 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.

4 Conclusions

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 (Kennewell et al. 2007). Most teachers adopting ICT use it for relatively authoritative teaching approaches, and our results suggest 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 Mercer et al. 2004) and more dialogic interactivity when used by individual students (Plowman 2005).

We have observed 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).

The first category is a familiar feature of the traditional classroom, but the adoption of ICT brings new forms of display for ideas, particularly dynamic forms which enable teachers to represent more clearly some of the more difficult ideas for learners to understand. It also enables teachers to have a much larger range of resources easily available, and to switch smoothly between these resources during a lesson (see Kennewell and Beauchamp 2007 for further analysis of ICT's features).

The second category is specific to the technology-enhanced learning environment, where resources are able to respond in a manner contingent on the learner's action, in contrast to traditional resources. This category can be subdivided into instances in which the ICT resource initiates the interaction (such as a quiz or challenge presented by a piece of software) and instances in which the learner initiates the interaction (such as simulations where the user controls variables and observes the outcome of the process simulated). Of these, the latter seems to provide more opportunity for dialogic interaction.

It is the third category that may best exploit the potential of ICT as a medium for dialogic teaching, however. Of course, 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 much more cheaply that an IWB, and a set of mini-whiteboards is easier than an electronic voting system to use in an unplanned way to gauge the range of ideas from a class. However, new technologies that can not only mimic but extend the affordances of traditional media are continually emerging and reducing in cost.

Teachers therefore 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 which they are likely to subvert.

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