TEACHERS' CLASSROOM INTERACTIONS IN ICT-BASED MATHEMATICS LESSONS

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Abstract *Do teachers' classroom interactions in ICT-based secondary school mathematics lessons differ from those in non-ICT-based lessons? This paper reports on data obtained from classroom observations of teachers who attempted to incorporate ICT into their lessons over the course of a school year. The analysis of the data does not indicate significant changes in teachers' classroom interactions in ICT-based lessons other than those that have quite straightforward explanations.*

Introduction

Do teachers' classroom interactions (roles, behaviours, communication) change when teaching and learning moves from 'normal' lessons to information and communications technology (ICT) based lessons? This question, while intriguing, requires clarification before an attempt at an answer can be made. The literature, however, often suggests a change in teachers' roles, e.g. Heid et al. (1990) state:

> In the implementation of computer-based laboratory explorations, the teacher must become a technical assistant, a collaborator, and a facilitator. ... the teacher will need refined skills as a discussion leader and as a catalyst for self-directed student learning.

This is a particularly strong statement chosen to make the point and the authors are clearly open to the charge of confusing an 'is' with an 'ought'. Farrell (1996) represents a more guarded statement:

> ...evidence suggests that teachers are holding on to the managerial roles while taking on some new roles (e.g. consultant, fellow investigator) when technology is used.

This paper reports on an analysis of videotapes of ICT and non-ICT mathematics lessons of 13 teachers. The analysis was part of a wider project and I begin with a brief overview of this project.

The wider study

The *Moving from Occasional to Regular Use of Technology in Secondary Mathematics Classes* project explored patterns of teaching and learning, teachers' preparation and use of resources, teachers and students' attitudes and teachers' confidence, over the course of one school year. 13 teachers made a commitment to move to 'regular' use of technology in the 1998/99 school year. Most had some experience using technology in their classes but none had made extensive use of technology before. Whilst I recognise the difficulties, if not the impossibility, of characterising 'ordinary teachers' these 13 were, in an everyday sense, ordinary teachers in ordinary schools. Project funds provided a financial incentive for schools/mathematics departments to be involved and ICT experts/enthusiasts who volunteered to be involved were excluded from the project. The 13 teachers were both the subjects of the research and teacher-researchers. Most of the teacher-researchers wrote of their experiences in a series of articles in the UK professional journal *Micromath* (volumes 14/3, 15/2 and 15/3, 1998/99).

'ICT use in mathematics classes' is a collective term for a diffuse range of software and hardware. In an attempt to focus on something common and manageable project work focused on using technology tools: spreadsheets, graphic packages and calculators and algebra and geometry systems. In an attempt to keep the project work as realistic as possible individual team members chose the tools they thought most appropriate for use with their classes. As these tools have widest application with classes studying algebra, upper secondary classes (14-18 year olds) were the focus of the project work (one project class per teacher).

Methodology

The project made use of a wide range of data collection and analysis tools but here I report only on aspects of data collection and analysis relevant to teachers' observed classroom behaviours. Apart from noting patterns in these behaviours *per se* I was interested in possible patterns of change over the course of a school year. For each teacher the lessons observed were with the same class, the project class. Our resources were not sufficient to observe every lesson over the course of a year. The maximum number of lessons it was considered feasible to observe and analyze was estimated to be four lessons per teacher, 52 lessons in total. It was decided that each teacher would be observed prior to starting ICT work. I refer to this as the 'base-line' lesson. Thereafter each teacher would be observed near the beginning, towards the middle and towards the end of the year in ICT lessons. With the exception of one teacher, where the last ICT lesson observation was not observed, this plan was carried out.

Lesson observation formats were discussed in project team meetings and the tool chosen for classroom observations was a modified version of the Systematic Classroom Analysis Notation (SCAN) (Beeby et al., 1979). It was decided that all lesson observations would be videotaped. A desire for consistency in records of lessons and considerable prior experience (often problematic) in videotaping lessons informed our practical decisions on how to videotape: the camera was stationary in a position that was as non-obtrusive as possible but which allowed the teacher and all the students to be seen; a remote cordless microphone was attached to the teacher; the camera followed the teacher whenever s/he was speaking. Although we were, subjectively, satisfied with suitability of the video recordings for SCAN analysis, there were some problems which should be noted: the visual image was centred on the teacher and students working away from the teacher were not recorded; the microphone picked up the teacher's words clearly but students' words were sometimes obscured; the camera did not always produce a clear image of written work or screen images which was the focus of discussion; technical problems in three of the 51 lessons resulted in much of the sound being unclear.

The remainder of this section describes the modified SCAN system and its standardisation and use in this research but first it should be noted that the length restriction on this paper prevent a full presentation the data. To avoid repeated reference to this fact I now collect together all curtailments, mergers and omissions.

- SCAN descriptors focused on student activity are not presented.
- A number of SCAN descriptors have been omitted.
- The SCAN descriptors explaining and facilitating have been merged in the Results section.
- SCAN data is presented for only three of the 13 teachers.
- Details of how the original SCAN was modified are not presented (these were not extensive).
- I have not subjected SCAN to criticism.

SCAN works simultaneously on three time scales – 'activity', 'episode' and 'event'. Lessons are viewed as a series of activities, e.g. teacher exposition, students working, teacher-student dialogue. Each activity is viewed as a series of episodes, e.g. coaching, explaining. Events sub-divide the episodes into social and linguistic categories, e.g. managerial, confirmation. I now provide a fuller description of activities, episodes and events referred to in this paper.

Activities: C - whole class exposition. Dn - dialogue, between teacher and a group of *n* pupils. D1 for one-to-one dialogue. D2/3 for teacher talking to a group of two or three students.

Episodes were essentially about what the teachers were doing, e.g. facilitating, explaining. We made a distinction between technological and mathematical foci in episodes. Thus two 'facilitatings', Ft and Fi, and two 'explainings', Et and Ei were introduced. Coaching, Co, or eliciting reasons/ideas from students was assumed to be mathematical and not technological.

The coding of the events were ways of describing what was happening on a small scale within an episode. It worked out that essentially each sentence or two was coded. The linguistic descriptors of the events were based on what the teachers were saying – an assertion, a; an instruction, i; a confirmation, cf. The questions, qi or qt, were the questions that the teachers were asking the pupils, not what the pupils were asking the teachers. (A confirmation, or rejection, was often the reply of a teacher to a pupil question.)

Question qualifiers described the level of the teacher's question, not the level of a pupil's question nor the general dialogue.

Nature or depth of question:

α - question requiring recall, single fact, single act, no processing involved

β - question of straight forward nature, putting together several facts.

γ - question extending of previous work involving new ideas

Situation or Level of guidance

1 - highly structured, close direction, small number of steps.

2 - some guidance, requires connections rather than selection.

3 - minimum guidance, open.

Coding were written into grids as below. The numbers denote minutes. 30 second blocks of time were the basic unit of analysis. Rows one and three were used to record, respectively, teacher and student, activity. Row two was used to record episodes and their linguistic descriptors and qualifiers.

			1		2		3		4	
T										
Ep										
St										

A research assistant and I spent over 20 hours coding 10 minute fragments until we reached 85% agreement. Thereafter the research assistant coded all tapes of lessons.

Results

Table 1 SCAN statistics for three teachers

	C	D1	D2/3	Co	EFi	EFt	a	i	cf	qi	qt	α1	α2	α3	β1	β2	β3	γ1	γ2	γ3	time
1	47	39		28	37		15	9	4	15		4				11					29
2	55	28	13	6	8	64			2	6	3	7				2					34
3	26	50	21		72	17	25	42	35	34	4	19			1	16	2				36
4	35	58	3		23	55	44	45	27	18	22	20			2	13				5	35
1	68	21		39	27		5	2	3	51		36	3			12					70
2	41	34		4	17	37	1	18	1	4	3	4				3					70
3	19	74		8	77		61	33	7	33		24	3		1	4			1		59
4	41	44	10		63	25	65	46	8	37	18	44	1			8				2	64
1	61	11		46	7		11	34		38		31				7					70
2	62	25		27	6	39	42	88	2	1	9	5				5					72
3	61	21			35	38	48	80	21	14	19	22	2			11					71
4	38	21			31	20	32	61	12	16	2	13				5					59

Table 1 shows SCAN statistics for the four videotaped lessons of three teachers. Column 1 indicates the lesson and the last column shows the length of the lesson in minutes. The codes for the other columns have been described earlier. Columns C to EFt represent percentage of lesson times. Columns $\alpha 1$ to $\gamma 3$ denote raw numbers of occurrences, e.g. teacher 1 in lesson 1 made 15 assertions.

Comparing the 13 non-ICT lessons with the 38 ICT-based lessons seven features stand out as markedly different. The figures below represent averages.

Table 2 SCAN statistics which show a marked difference over all 13 teachers

	non-ICT	ICT
(1) the percentage of time spent in teacher-whole class exposition (C)	48%	19%
(2) the percentage of time teachers spent talking to two or more students (D2/3)	28%	45%
(3) the percentage of time teachers spent coaching or eliciting ideas from students (Co)	19%	4%
(4) the percentage of time teachers spent explaining or facilitating mathematical ideas (EFi)	44%	29%
(5) the percentage of time teachers spent explaining or facilitating technological features (EFt)	0%	24%
(6) the number of assertions teachers made during lessons (a)	9	35
(7) the number of instructions (or initiating remarks) teachers made during lessons (i)	15	50

Discussion

I address issues relating to Table 1 and Table 2 before considering claims for and against changes in mathematics teachers roles, behaviours and interactions in ICT lessons.

While the project teachers had a number of common characteristics they also had many differences shaped by their attitudes to mathematics and to ICT, the ethos of their school and of their department and by their classes. The three teachers in Table 1 were selected to show differences whilst being representative of the 13 teachers. Teacher 1's project class were 14 to 15 year olds. The ICT lessons used a spreadsheet and a graphic package (principally for transformations). She used ICT almost every Tuesday of the project year. My own subjective reaction after her first observed ICT lesson was that she had imported her normal classroom technique to the computer room. Teacher 2's project class was an Advanced level class of 16 to 17 year olds. The ICT work focused on using *Derive* but spreadsheet and a graphic package was used as well. He 'blocked' his ICT work with the class, i.e. there were periods of intense use and periods of little use. He stated that he wanted to use *Derive* as a ‘teach yourself’ tool to break away from the norm of ‘chalk and talk’ with this class and he designed worksheets to assist him with this aim. Teacher 3’s project class were 14 to 15 year olds who had a graphic calculator each during ICT lessons (but they did not take them home). As with teacher 2, ICT lessons were ‘blocked’. ICT lessons observed were predominantly teacher led with the class imitating the teacher’s key strokes. Again my subjective impression after the first observed ICT lesson was how similar his style was to his teacher-led style in non-ICT lessons.

My subjective impressions of similar styles in the first ICT and the non-ICT lesson of teachers 1 and 3 is, to some extent, borne out by a comparison of figures in the C and D columns for these two lessons of these two teachers. Later ICT lessons, however, show less whole class teaching. Against any effect or non-effect of ICT, however, it may simply be that mathematics teachers do less exposition later in the year as they become more familiar with a class.

The $\alpha 1$ to $\gamma 3$ columns of Table 1 are interesting but, perhaps, not surprising, because of the clustering in columns $\alpha 1$ and $\beta 2$. SCAN is not an instrument for discourse analysis, so statements about teacher-student discourse must be guarded. However, the very few $\gamma 3$ occurrences in ICT lessons must question any general claim that teachers become fellow investigators in ICT lessons. Where they do occur, however, they occur in ICT lessons and in later lessons (but again teacher-student familiarity over time could be a factor).

Table 2 shows some marked general differences between ICT and non-ICT lessons but, I believe, these can be explained in most cases in very practical ways. All 13 video-taped non-ICT lessons were of the form ‘teacher exposition followed by students working on exercises’. The significant reduction in teacher-exposition in ICT-based lessons, (1), may be viewed partially as an organisational factor in that six of the teachers prepared their classes before they moved to the computer room. The percentage increase in time that teachers talked to two or more students, (2), largely reflects the fact that the availability of computers forced students to work with two or more to a machine. It is interesting to note, however, that even when students worked in pairs in non-ICT lessons the teacher talk was largely directed to one of the pair but in ICT-based lessons the teacher talk was largely directed to all students around a computer. The significance of the coaching figures, (3), lies in the relative absence of this in ICT-based lessons. I must admit that I cannot explain this but coaching in all lessons was interpreted as the teacher pointing out mathematical features without revealing the answer and a relative absence of this in ICT-lessons does not, to me, suggest that the teachers are acting as ‘a catalyst for self-directed student learning’. The figures in (4) and (5) have obvious explanations in the ICT, or not, focus of the lesson (if you do not have ICT in your classroom, then you are not going to . The figures in (6) and (7) represent the average number of assertions and instructions teachers made. These averages conceal great variation over teachers and different lessons. One reason for the greater average in ICT-based lessons was an apparent propensity in ICT-based lessons for six of the teachers to move quickly around the class ensuring that technical problems did not slow work down, “copy cell B3 to D3”.

There is thus a discrepancy, with many papers reporting “Clear changes in social behaviour and teaching methodologies could be seen by observation of the [computer] lessons” (Schneider, 2000) whereas, apart from changes resulting from quite straightforward reasons, this was not observed to any marked degree in the reported study.

One possible reason for the apparent discrepancy is that projects which report on changes in teachers’ roles focus on teachers who are technology enthusiasts. The teachers in this project were volunteers who wanted to use ICT in their teaching, so there is likely to be something else at work here. One thing the project teachers had little prior experience of was of using ICT in their mathematics lessons. I suspect that the time factor of experience is important (as commented above, Table 1 shows that later ICT lessons involved less whole class teaching.). In this context time is not just time learning how to use ICT tools but time to get ‘a feel’ for how lessons will run by having tried things out. As Moriera and Noss (1995) put it:

> Developing a coherent pedagogical approach for learning with computational media is a far from trivial exercise. Time is an important factor ... it is more a matter of ‘*taking time to percolate*’ than just to locate or create new working environments for pupils.

It must also be considered whether SCAN, or my use of it, is a reason for the discrepancy between my findings and other work. SCAN is certainly quite a clumsy tool for analyzing teacher-student discourse and I used it in quite a crude way to make frequency counts but every effort was made to ensure reliability and validity.

My final consideration in this section concerns innovation. A danger for researchers in the field of the use of ICT in mathematics classes is a tendency to believe that ICT innovation is somehow unique. Prestage (1996) made a study of teachers’ perceptions of sequencing and progression as they implemented changes introduced by the UK National Curriculum. She claimed the teachers worked in three phases over time: (i) trying to accommodate the (assumed) givens without questioning, (ii) making sense of the (assumed) givens, (iii) trying to accommodate the (now personally interpreted) givens within their own frameworks for teaching and learning. My point in introducing Prestage’s work is that there are similarities with my comments above on experience and time and that ICT innovation shares problems with other types of innovation. Cuban (1989), in a reaction to a computer symposium where claims were being made about changes in teachers’ roles, drew parallels to earlier 20th century educational technology innovations (films, radio, television) and stated that “teachers teach the way they do simply to survive the impossibilities inherent in the workplace”. Cuban may be overstating the case but all 13 project teachers saw their practice as supporting external curriculum and assessment criteria and felt a moral obligation to their students that ICT work had to support learning which would be assessed without ICT. Their innovative work had to support traditional norms. In such conditions it is hardly surprising that there were no significant changes in these 13 teachers' classroom interactions in ICT-based lessons other than those that have quite straightforward explanations.

The conditions and constraints that teachers work under point to the need for further research in this field. Like Cuban (1989) I do not think it is enough to expect that a machine will affect teachers' classroom interactions. Researchers and policy makers should be looking at how the curriculum and school structures might allow for new roles for teacher-student interaction – with and without ICT.

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References

Beeby, T., Burkhardt, H. & Fraser, R. (1979) *Systematic Classroom Analysis Notation for Mathematics Lessons*. Nottingham: Shell Centre for Mathematical Education.

Cuban, L. (1989)Neoprogressive Visions and Organizational Realities. *Harvard Educational Review*, **59**, 217-222.

Farrell, A. (1996) Roles and Behaviours in Technology-integrated Precalculus Classrooms. *Journal of Mathematical Behaviour*, **15**, 35-53.

Heid, M.K., Sheets, C. & Matras, M.A. (1990) Computer-enhanced Algebra: New Roles and Challenges for Teachers and Students', in Cooney, T. (ed.), *Teaching and Learning Mathematics in the 1990s, NCTM 1990 Yearbook.* Reston,Va.: NCTM.

Moreira, C. & Noss, R. (1995) Understanding teachers' attitudes to change in a Logomathematics environment. *Educational Studies in Mathematics*, **28**, 155-176.

Prestage, S. (1996) Teachers' Perception of Sequencing and Progression in the Mathematics National Curriculum, in: D.C.Johnson & A. Millet (Eds) *Implementing the Mathematics National Curriculum: Policy, Politics and Practice* (London, Paul Chapman).

Schneider, E. (2000) Teacher Experiences with the Use of a CAS in a Mathematics Classroom. *International Journal of Computer Algebra in Mathematics Education*, **7**(2), 119-141.