Secondary mathematics departments making autonomous change

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In the *Changes in Mathematics Teaching Project*[1] three mathematics departments made autonomous changes to their practice in KS3. We chronicled aspects of their practice, tracked a focus sample of students, and obtained KS3 results for the cohort. This paper reports characteristics of the department activity and identifies common features and difficulties which may be associated with the effects of the changes.

Keywords: collaborative practice; teacher change; low attaining students; subject departments

Introduction

This paper reports on the common characteristics of three secondary mathematics departments making deliberate changes to the ways they taught, with the intention of improving the learning of previously low attaining students (PLAS) – that is those who scored at or below a low level 4 in KS2 SATs – during KS3. These changes led in two cases to significant increases in test results for the whole cohort at KS3, and in the third case to sustaining previous levels while other core subjects declined. Several aspects of their work were analysed to identify features that may have contributed to this success. This study is a contribution to knowledge of how mathematics departments can act as self-developing subject communities. They also had at times to resist some attempts by senior management teams to impose other practices on the teachers. It is also worth noting that they were not involved in specific development projects such as lesson study.

What is special about mathematics departments?

School subject departments operate in similar ways for many purposes as social and learning communities (Hodkinson & Hodkinson, 2005), whatever the subject, but we might expect them also to be distinguishable through characteristic epistemic cultures (Knorr-Cetina, 1999). They would also be distinctive in ways which relate to current issues in school mathematics teaching in England: shortage of teachers; high turnover of teachers; pressure for results because schools are compared using mathematics test results; a high political focus; inherent cognitive and emotional difficulties in learning the subject; and a larger body of research about learning maths than for many subjects. The departments on which this paper is based were also distinctive in being subjects of research. One head of department told us: ‘we kept going because we knew you were coming in and would ask what we had been doing’, and on another occasion: ‘it’s good to talk to someone outside about what we are doing.’

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The study

All three schools contacted us separately to tell us what they were doing because they had been influenced by an earlier project (Watson and De Geest, 2005). Our decision to research their changes was thus opportunistic. The approach taken was non-interventional, and ethnographic in that we watched and listened and asked people about what was going on in their practice. The research team collected data from four main sources:

- interviews, observations and video of teachers and heads of department
- observation of some department and other meetings and inservice events
- interviews with a sample of previously low attaining students (PLAS)
- data, materials, tests and marks, pertaining to the whole cohort.

The changes that were made were initiated by the departments or at least by the heads of departments. They all focused on the cohort that started year 7 in 2005, and they all introduced new schemes of work, new ways of teaching and all-attainment groupings for that cohort. The grouping decision was taken for three different reasons: for timetabling expediency, for an equitable 'fresh start' for everyone, and for the opportunity for teachers to work as a team with parallel groups. One school (SP) continued to teach all-attainment groups in year 8 while others introduced loose setting with highest and lowest attaining students in separate sets. All schools used setting for year 9. Research comparing mathematics teaching using different groupings is always confounded by related changes in teaching, but in this study the approaches to teaching which were developed for all-attainment groups were mostly, but not totally, sustained throughout all three years in various forms.

From the last two data sources we learnt that PLAS developed and maintained a positive approach to mathematics lessons and their own achievement on the whole throughout the three years. Also test scores for PLAS were significantly higher than previous years in two schools (SP and LS), but not in the other. Overall for the whole cohort, test scores at KS3 improved significantly in two schools and were maintained in the third against a background of falling scores across the other core subjects (FH)[1]. The combination of the test scores, the significant improvement for PLAS in two schools, and the reported positive attitudes make it worth knowing more about the departments' work. This paper relates to findings from the first two data sources.

Analysis

We interviewed consenting teachers up to three times during the study. Those who taught the cohort every year were interviewed three times, but due to staff changes and deployment decisions several teachers were only interviewed once or twice. The qualitative data collected from semi-structured interviews about their practice, their teaching and how the departments worked were analysed using a frame devised from activity theory in which each teacher's responses were sorted according to whether they were about how the department activity, or about classroom activity. The activity theory perspective focuses primarily on the role of tools in shaping and being shaped by the object of the collaborative work, the improved learning of PLAS, and is also concerned with the roles and authorities within the system. It derives from a view of human collective activity in which systems inevitably contain contradictions which give rise to adaptations in the system. The work of the system is divided among

[1] More details can be found on www.cmtp.cp.uk

individuals and coordinated in the community to achieve shared goals. Individual variations are either subsumed or they contribute to contradictions[1].

For both department and classroom activity, utterances were further sorted according to whether they referred to the purposes of the activity, the people, the tools and other mediating mechanisms that brought about that object, how the community operated in terms of its members, rules, expectations, and how tasks were carried out. Thus for each teacher we had one, two or three sets of data about departments and classrooms that could be collated with other teachers. Where we had two or more years' of interviews we could also look for changes in what individual teachers talked about. Other qualitative data from observations of meetings were analysed under similar headings and added to the overall picture of departments emerging from the sorted data, and also to our own observational knowledge of what changed during the three years. Space is too limited to expand on this process here[2]. Here we further synthesise the data to identify overarching characteristics and difficulties. Our use of the analytical triangle derived from Engestrom (1998) follows its application to school mathematics departments by Venkatakrishnan (2005). She described the activity of a department acting under imposed change using the triangle to show how the department and its local authority systems, while apparently using the same tools, appropriated them in different ways.

Describing the departments' work

In our interviews teachers often talked about connections between the features of their work which are usually represented by the vertices and midpoints in Figure 1. Some of these connections were about individual actions, such as interpretation of tool use, or individual planning, while others expressed how external pressures can constrain the nature of these connections, such as the assessment regime constraining the object – students' improved learning – in ways that were nothing to do with the department system. There were similarities in teachers' talk about individual actions and influences and we saw this as a kind of shadow overlaid onto the triangle giving meaning to the lines. Thus we could include in the diagram the fact that individuals are driven by their interpretations, yet these both shape and are shaped by the system within which they work. The labels on the links in Figure 1 indicate that most teachers talked about their relation with tools as communication and creation; that individual decisions affect the way they enact the object; that their position in the department affects the work they do; the importance of personal professionalism; their responsibility to the school and parents; and relations between various regimes and autonomy.

Changes in object, tools, expectations and labour

In this section we describe common changes during the study which we synthesised by comparing departments over time. The *shared object* of the work of the departments and the classrooms was to improve mathematics learning of PLAS, but the nature of this learning was described differently at different times during the project. At the start, the object was usually described as 'develop mathematical thinking, make mathematics fun, help them believe they can learn maths' but towards the end of the first year the majority of teachers added comments such as 'help them

[1] There is not space here to give a more detailed account of activity theory, see Jaworski & Potari (2009) for a thorough account applied to the work of mathematics teaching.
[2] We have written elsewhere about this analytical process (Beswick, Watson & De Geest 2007).

be confident about the basics' to their descriptions. Later still, some teachers from all schools were also talking about 'working on key ideas'. These shifts of focus in the object were reported to us, sometimes as if they were dissenting views, but we learnt from our the discussions at department meetings that all schools did, to some extent, pay more specific attention to arithmetical understanding about half way through the project than they had at the start. These changes of expression of the object then generated changes of *expectations* and the nature and use of *tools*.

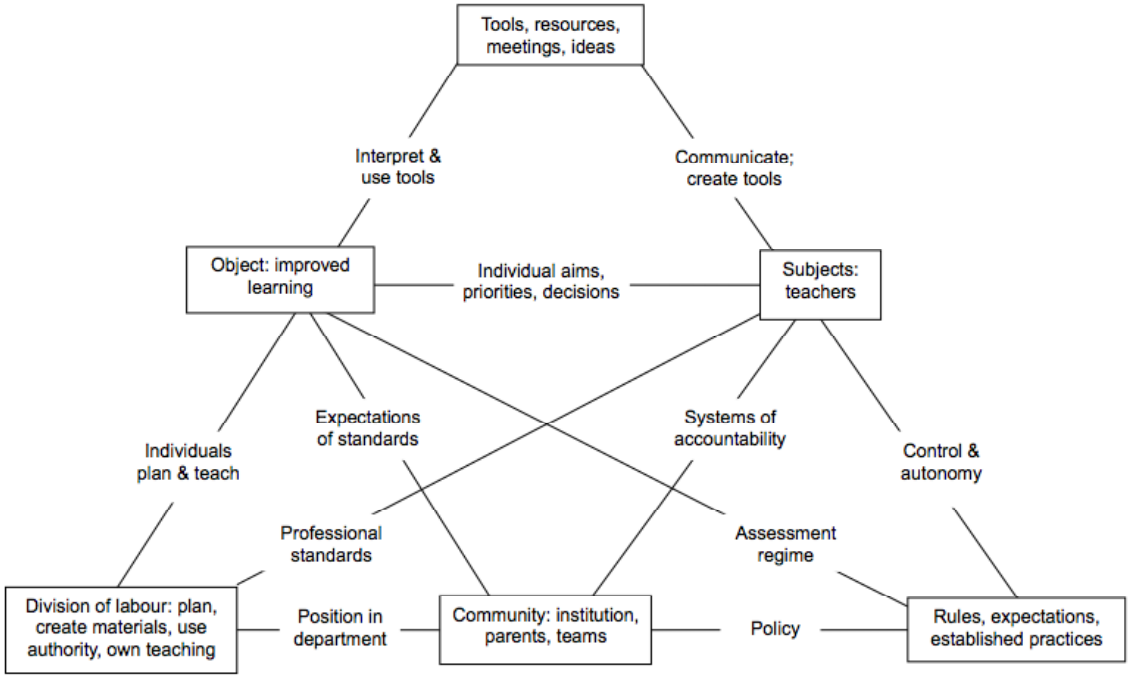

Figure 1: The activity of mathematics departments making autonomous changes to practice

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In school LS a day-long end of year review of year 7 work focused on the need to give students more experience of questions that required multi-staged reasoning, and also to shift teachers' discussions from task selection and design to thinking about what students were expected to learn. They believed that they had by then established ways of working and thinking as classroom norms and now, maintaining those norms, needed to move away from the 'how' and think harder about the 'what'. A similar but less explicit shift took place in the other two schools and we noticed that this was combined with a shift away from using open-ended exploratory tasks from published materials towards internal development of resources with specific curriculum foci, and attention to language, examples and methods that might be taught and learnt through teacher-generated tasks. At the start of the project, therefore, the shared tools were mainly published materials promulgating open-ended approaches, but teachers individually and collectively shifted the object to include learning specific mathematical ideas. This shift was supported by, and also influenced, changes in what teachers regarded as their resources, so that the knowledge of the community was treated as the main resource, and the action of communicating and developing that knowledge became the main activity of the department, rather than being caught up rules and expectations about who should produce what and 'put it in the resources file'. When we analysed the *division of*

labour in the department, we were initially ourselves caught up in stories about what was supposed to happen rather than what did happen, so we perceived these stories as 'rules' or, rather, 'expectations' within which teachers worked, while in practice they did other kinds of sharing. The category 'expectations' arose during analysis because these were internally-generated pragmatic understandings about roles, but recognition of pressure on teachers' time in school meant that all HoDs were good humoured about whether these were achieved or not.

Department meetings had a multiple function, attendance being part of the overarching rule-structure for teachers, but they acted as a keystone for the community, holding other aspects of activity in balance with each other. They also functioned as a kind of resource, being the forum for discussion and dissemination that was available for all teachers, even those who were not always around for informal interaction. Meetings with others, and other people's knowledge, came to be used as major *tools for change*, whereas typical mathematics department resource banks were the ordinary *tools for maintaining teaching*.

All the innovations were seen, to various extents at various times, to be in conflict with senior management teams, the inspectorate, beliefs about 'what we are supposed to do', students' previous experiences of mathematics teaching, parents, and also with the views of a small minority of teachers. These 'outsiders' could exert influence through rules, through their position embracing the department in a wider *community*, and through the tools they provided for teachers to use.

Common practices

By about the middle of the second year these changes had become embedded for most teachers. For all schools the approach to planning was internally prescriptive, but different in nature to the scheme of work set out in the National Strategy. For example, SP developed a module of work on logical reasoning, while LS agreed a school-wide approach to teaching equations, starting with the balance metaphor, which would permeate all their teaching. Mostly, teams were united together in seeing their practice as in conflict with 'the strategy' or 'the framework' because in year 7 at least, and to some extent in other years, attention was more on developing mathematical behaviour by spending extended time on core mathematical ideas using a variety of short and long tasks than on coverage of a number of specific topics.

There were other common features which, from our experience, might distinguish these departments from some others:

- The focus on the study cohort was made explicit at certain times which were ring-fenced in various ways; for example, extra department meetings, inservice days devoted to planning for the cohort, major meeting agenda items
- All departments undertook overtly critical use of official documents; in two schools new teachers were enculturated into critical professionalism; in the third a core group of experienced teachers were already critical professionals
- All departments focused on key ideas in mathematics and/or mathematical thinking (albeit defined in different ways by different teachers)
- All departments had a culture of frequent informal discussions about teaching mathematics – whether they had a dedicated subject staffroom or not.
- Small teams created, collated and disseminated resources.
- All departments provided protected timetabled time for co-planning where possible, and all used email prolifically.
- Departments shifted from talking about tasks and activities as if they would somehow 'deliver' learning to developing focused teaching approaches

- The presence of new teachers was seen as important to stimulate talk
- Planning cohered around discussion of parallel groups and also vertical planning, so that students' experience would be coherent year-on-year
- Nearly all teachers were willing to abandon their own past approaches in order to have coherence throughout the school
- All departments included core members who overtly learnt together
- Several members of each team were well-informed, read professional literature and sought research-based approaches to teaching

It is clear from this list that most of the teachers had a strong commitment to the shared aim, and also to some extent saw themselves as 'against' some outside authority. There was also a levelisation of teachers' roles in relation to the study cohort, in that the emphasis was on shared development of teaching and contribution was seen in relation to the time one was willing to spend on the work rather than on qualifications and experience.

Formal meetings were carefully planned by HoDs. Departments discussed particular mathematical topics in depth at these meetings, and often this would include sharing ideas about what the important features were and how they related to other topics. All departments did mathematics together, and this promoted pedagogic discussion best when the shared focus was on classroom tasks rather than on mathematics for personal professional development. Such discussions often revealed different perceptions of the subject matter. Teachers would often review recent teaching and revise approaches for the future, and these discussions also revealed different perceptions of the subject matter. Meetings were not used as a conduit for management information. Organisational and information matters were dealt with by email or informally, not generally in meetings. The teamwork, internal networking, collaboration and use of knowledge from outside networking which took place in the departments appeared to have arisen because of the nature of the department meetings, which were collegial and professional rather than managerial and coercive.

Critical difficulties and differences

School SP had the most stable team, the most stable student population, maintained all-attainment grouping for longer, and had the least disagreement among teachers. This was the school which had the strongest sharing of ideological commitment to the methods adopted, and also in which the head of department took the strongest critical stance towards external imposition. It also had the highest increase in test scores and was the only school to make a statistically significant difference for the weakest of the PLAS. While this confirms the central importance of belief in raising achievement for PLAS (see Watson and De Geest, 2005), this school also had by far the lowest previous test score level, so had more room for test scores to rise.

School FH had the least stable team, including a change of head of department after the first year. In practice, the department changed its focus from the study cohort to the subsequent cohort, so that the maintenance of test scores when compared to falls in other core subjects, while being a great achievement, was not due to a strong department focus after year 7. From teacher reports we think that input in year 7, followed by a spread of new practices to all years could have contributed. Another feature is that of the three schools this one had the highest scores before the study, and hence the least space for improvement.

In all schools there had been dissent among some teachers at the start of the project, but in SP dissent evaporated, with teachers self-reporting their changes of mind. In LS we could not learn much about dissent because the dissenting teachers

had not agreed to participate in the study. In FH we learnt more about dissent because it was overtly expressed to us as covert disagreements with HoDs. There were two main issues that emerged from our observations: *leadership style* and *marginalisation* of teachers.

The heads of department took various roles during the study in relation to their departments: overt change agent, inspirer-leader, presenter, participant, listener, tea and cake provider, and learner. The first kind of leadership appeared to generate most dissent and obstruction, while the other kinds appeared to be accepted and understood. Of course, all HoDs were change-agents and managers, but their role in formal and informal discussions tended to be more as team players. In one case, the HoD genuinely asked a less experienced colleague to help her sort out her management of one class. We noticed that the team participated more in discussion of mathematics when leaders took the role of listener and learner and others presented the mathematical tasks to be undertaken. HoDs would often ask colleagues to prepare tasks or brief talks and presentations for meetings. There were also times in all schools when an HoD or other teacher would present an inspiring insight or observation from research or reading.

When teams work as closely and coherently as these did, the difference between core members and marginalised members becomes very marked. We were able to identify four kinds of marginalisation, which may overlap:

- Institutional: teachers who have other roles in school, only teach mathematics for part of the time, and hence are not around for informal discussions and may not attend all formal meetings
- Ideological: teachers who have reasoned differences with the department policy and voice this either in meetings or outside meetings; they may or may not act out department policy and are unlikely to use available tools for change
- Epistemological: teachers who have a different view of mathematics and may not understand some of the public discussions about mathematics learning
- Self-imposed: teachers who choose not to take part in informal interactions or other opportunities for team membership; they may or may not attempt to act out department policy and are unlikely to use available tools for change

Non-specialist teachers are not necessarily marginalised nor are marginalised teachers necessarily non-specialist. Differences between specialist and non-specialist teachers are indicated by our lesson observation data outside the scope of this paper.

Differences among teachers were not discussed explicitly in departments. For example, teachers were reluctant to challenge each other about mathematical knowledge. This means that some teachers continue with limited or sometimes incorrect mathematical ideas even when working among strong mathematical colleagues. Heads of department who display their own need to learn openly seem most likely to generate helpful talk about mathematics. Teachers were also reluctant, but less so, to challenge assumptions about limitations of students' capabilities in relation to hard mathematical ideas. We witnessed one meeting in which a teacher talked of her class being able to tackle complex tasks but other teachers, who taught parallel groups, claiming that theirs could not be helped to do so. There seemed to be no mechanism in the discussion to examine these differences. At other times, teachers appeared to be conversing about similar issues but when we listened to audio recordings we noticed that some teachers talked about how students *think* while others talked of what they will *know*, and some teachers anticipated what students might *learn* while others talked only of what they will *do* – yet conversation continued as if there was shared meaning.

In FH, after the cohort was reorganised into sets in year 8, one group with the lowest prior attainment was taught by a teacher who exhibited characteristics of three kinds of marginalisation. The teaching methods were not in accord with department ideas and agreements. The decision to staff lowest attaining groups with marginalised teachers is often forced on HoDs by school constraints, and is likely to continue, however a core teacher took the group over for year 9. The relevant sample students exhibited a slight dip in attitudes in year 8, and recovered in year 9. This school was one that had insignificant changes in test result at KS3, and no improvement for PLAS. In terms of our study, therefore, FH could be said to have failed in their initial aim, but as that aim had been abandoned until the following cohort, and a key teacher did not share the aim, we prefer to think instead about how those who taught these students in year 9 rescued some attitudes.

Reflections

When departments decide for themselves to undertake change, the processes are necessarily complex. The successes of these departments are due to collaboration, but we have shown by analysing their activity that this was of a special kind. It was not an imposed structural mechanism for change, nor was it generic; instead it was grounded in mathematics teaching and participants worked together equally and informally around planning through discussion of mathematical tasks. It took time for them to settle on new objects of activity, and to identify and use tools for change in their interactions. Due to various kinds of marginalisation full collaboration was not achieved, but mainly these teachers acted together and were willing to give up their own ideas for the collective work. Teachers participated professionally in the development and use of agreed teaching ideas and resources, and resisted outside pressures to various extents. Our analytical frame allowed us to describe aspects of their complex work and to observe what changed over the three years.

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