THE CENTRAL ROLE OF THE TEACHER – EVEN IN STUDENT CENTRED PEDAGOGIES

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We describe a case study of an unusually 'student-centred' mathematics teacher whose students construct unusual – and positive – mathematical dispositions and identities. We draw on a self-report 'teacher-centred pedagogic practices' scale, interview and classroom lesson analyses to identify her pedagogic practice and her reflections on these. Our analysis distinguishes 'mathematical' and 'social' strands in her narrative within lessons which ensure that whilst her practices are found to be engaging and ensure agency and choice she maintains firm control over the 'mathematical narrative'. In this sense her practice appears contradictory: Activity Theory suggests this as an objective contradiction between the learners' knowledge and the mathematical reformulation of it that the teacher mediates.

INTRODUCTION

The UK Economic and Social Research Council funded project, 'Keeping open the door to mathematically demanding courses in Further and Higher Education' is investigating the effectiveness of two different programmes of mathematics for post-16 students in England. This involves both case study research investigating classroom cultures and pedagogic practices and students' narratives of identity together with quantitative analysis of measures of value added to learning outcomes. In this paper we focus on teachers' classroom practices as we attempt to come to an understanding of how different practices impact on students' engagement with mathematics in such courses and their future studies.

THEORETICAL PERSPECTIVES

International studies such as TIMSS have analysed mathematics lessons in an attempt to characterise typical lesson structures and flows across different countries. Stigler and Hiebert (1999), for example, suggest that mathematics lessons within a particular country will tend to develop a common format that forms part of the national culture and may be difficult to alter. Our intention, however, was to look for diversity of practice within and across colleges as our ongoing analysis attempts to identify and understand practices that might better support students' learning. We have a particular focus on students in danger of marginalisation from mathematics, as ultimately we wish to inform policy makers and teachers as to how they might structure curricula and implement pedagogies to maximise participation and attainment.

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It is clear that teachers' beliefs are fundamental in shaping aspects of their classroom practice, but practices also reflect the historical and social setting in which they are constructed and situated. For example, our case studies suggest that colleges position themselves differently in their "local market-place" for students, who at this level are able to shop-around amongst providers looking for those who are best able to provide for their needs. Some colleges, therefore, have open access attempting to provide for all learners regardless of their ability whereas other colleges position themselves as high achieving institutions and will take only the most able students. Such positioning we find acts in affording or constraining teachers' practices at all levels including in their mathematics classrooms. Our concern here then, whilst recognising potential institutional and programme filtering (programme design being another important filter), is to focus on teachers' pedagogic practices. We have therefore built on the work of Swan (2006), who in turn developed the work of Askew et al. (1997) to explore the practices of teachers with different orientations: transmissionist, discovery and connectionist. These different categories reflect varying degrees of emphasis on teaching (with a strong teacher focus) and learning (with a strong student focus).

As we report elsewhere (for example, Pampaka et al., 2007; Wake et al., 2007) there is evidence that teaching that is strongly student focused (connectionist) might better serve those students at risk of marginalisation from the study of mathematics. Our concern here, however, is to explore what such teaching might look like in practise and start to understand some of the key features of appropriate pedagogies.

'TEACHER-CENTRICISM'

We constructed a new instrument based on Swan's items (2006) but following a different analytical methodology resulting in a uni-dimensional scale of 'teacher centrism'. A detailed account of the development of this instrument and the validation of the constructed measure is reported elsewhere (Pampaka et al., 2008). A total of 110 cases/teachers were used for the validation of the measure based on statements about classroom practice with analysis allowing the development of a scale in which both items and respondents could be mapped together (Figure 1). The histogram on the right hand side shows how the teachers were distributed and identifies those whose self-reported pedagogy is mainly student-centered at the bottom of the scale to those whose pedagogy is mainly 'teacher-centered' at the top. On the left hand side of the figure the items that constitute the scale are distributed, ranging from the easiest to report frequency of occurrence (bottom) to the most difficult in this sense (top).

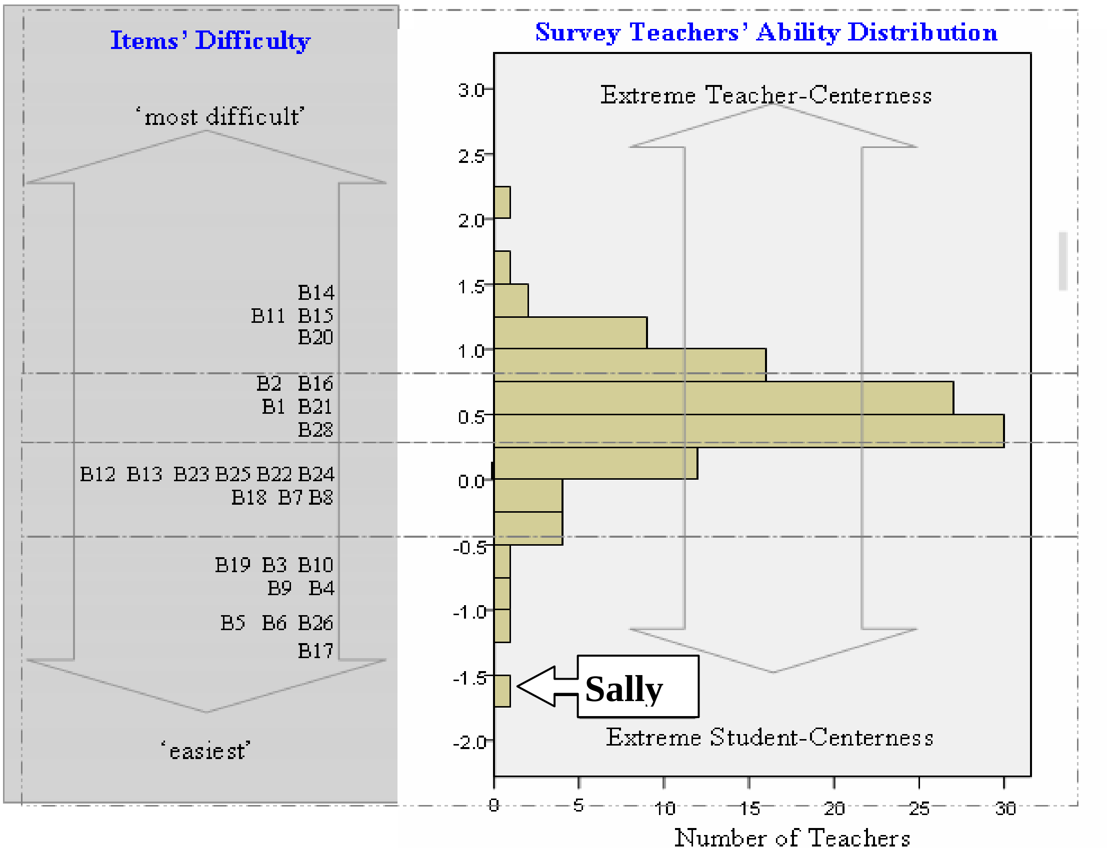

Figure 1: The 'teacher-centrism scale'

The figure is best interpreted considering both teachers and items together: having located a teacher on the scale, it is likely that they are able to agree relatively easily with statements below their position but have difficulty agreeing with items above (with statements being ranked in increasing order of teacher-centrism). 'Difficult' statements such as B20 ["I encourage students to work more quickly"] are more easily endorsed by teachers that are located at the high end of the scale who are more teacher-centred in their practices than student-centred. As can be seen practices denoted by 'easier' items, such as B17 (reversed) ["Students (don't) invent their own methods"] are likely to be endorsed by the vast majority of teachers.

In the brief space available here we focus on what a highly "connectionist" or student centred mathematics lesson might look like. We turn, therefore, to the teaching of Sally who works in England in one of our project case study colleges. As can be seen in Figure 1 Sally is the teacher who reports her practice as being most student centred lying at the very bottom of our measure of 'teacher-centrism'.

Sally, has difficulty in self-reporting her practices as being teacher-centred. In just this brief extract from an interview with her, for example, she rejects the teacher centred statements "I tend to follow the textbook closely" [B14] and "I (don't) draw links between topics and move back and forth between topics" [B11] of our scale.

> "from the teachers that I've met and talked to… it seems to me that one of the big differences is, I mean I don't sort of use textbooks…that makes me different to start with…in that sense. The reason why I don't use them is because…I want to get students

> to think about the maths, I want students to understand, I want students to connect ideas together, to see all those things that go together and I don't think a text book does that…"

The following report of her practice is based on classroom observations over a number of Sally's lessons carried out in the ethnographic tradition with video and audio recordings being supplemented by observational notes and follow-up interviews with students and teacher. In total we observed eight of Sally's lessons totalling 670 minutes. Here we report just the first part of a sequence of teaching in which the class starts to explore transformations of the graphs of quadratics. As the descriptive account that follows shows her practice clearly demonstrates why she rejects other teacher-centred statements such as "Students (don't) discuss their ideas" [B15] and "Students work through exercises" [B1].

NARRATIVES IN LESSONS AND OF MATHEMATICS

Although the instrument we use to characterise a teacher's orientation focuses on distinctive pedagogic practices such as whether or not the teacher relies heavily on a text book, or students work collaboratively in small groups, we suggest that to better understand the students' experience, and in particular, in terms of mathematics we need a different framework or lens through which to view a lesson. In an attempt to do this we turn to the construct of "narrative", in the sense of Ricouer, and as developed in educational settings by Bruner (1996) and others. We conceptualise the teacher as "narrator" revealing a mathematical plot whilst drawing on a range of pedagogic practices in an attempt to engage his or her audience in different ways. This allows us to focus not only on the method of engagement chosen (often a dominant feature when making classroom observations, as Shulman (1986) pointed out) but also the structuring of the mathematics; in other words, the story that the teacher tells about this. Pietig (1997) argues that essentially every mathematical argument, however presented, has a pedagogic function vis-à-vis the intended audience. We attempt to build on this, suggesting that pedagogy must have narrative, and therefore that any effective mathematical pedagogy or argument must have a genre of narrative. In an attempt to characterise different genres we suggest that in classrooms a teacher's narrative might be considered to have two different dimensions: a mathematical dimension based on the distinctive way in which the teacher unfolds their particular story about the mathematics at issue and a social dimension that comprises of two sub-dimensions involving (i) the social discourse between those involved and (ii) the different practices in which they engage. Further details of this framework and its use in describing lessons can be found in Wake et al. (2007).

STUDENT CENTRED PRACTICE

Sally's classroom is spacious and the walls are covered with posters her classes have made in previous lessons: these are working documents rather than polished artefacts and students tell us they refer to them in later lessons using them as publicly displayed notes. Students sit in groups around tables and at the start of this lesson in addition to their own stationery equipment each has a small (mini-) whiteboard, pen and cloth. Sally's classes use these regularly to respond to questions she asks: sometimes there is a public display of responses with students holding their mini-whiteboards in the air, at other times Sally will quickly sweep around the room monitoring students' working on their mini-whiteboards whilst she decides how to take the lesson forward. The classroom environment is designed and arranged by Sally to allow for students to engage easily in pair, group and whole-class discourse and using a range of 'sociable' pedagogic practices.

The lesson starts with Sally showing the graph $y = x^2$ on the (interactive) whiteboard at the front of the room, asking for its equation: an initial suggestion of $y = x$ is met with the response from Sally, "nearly", and is quickly followed by the correct answer. She asks everyone to write on their mini-whiteboard a point that lies on the graph and selects some responses which she writes alongside the graph. There follows some discussion with two students contributing about how one would know whether or not a point would lie on the graph if it was not clear from inspection or there were no grid lines to assist. In a follow-up interview Sally considers this an important starting point as she is aware that students up until this point have often been used to a procedural method of plotting graphs of functions by developing a table of points.

Sally then shows a different graph ($y = (x - 2)^2$), and asks the group to write down some points on this and decide on its equation, checking that their chosen points fit this. Sally selects the points that one student had written on her mini-whiteboard and writes them alongside the graph at the front of the room. She asks students to check that these points fit their equation and if not try adjusting this as, "every point has to fit". After a short while students are asked to hold their boards up and Sally makes a selection ($y = 2x^2 + 4$, $y = 2x^2$, $y = x^2 – 4$) of their suggested equations to write alongside the graph at the board. Although one student suggests that the point (0, 4) fits the first suggested equation ($y = 2x^2 + 4$), another is spotted by Sally shaking his head and asked to explain his problem: he suggests that none of the other points fit this particular equation and therefore it is not valid. Sally then checks whether (2, 2) fits, verbalising each step of the calculations as she starts with $x = 2$ leading to $y = 12$, rather than the required $y = 2$. Discussion moves to the next selected equation with students now suggesting whether it is correct or not to the whole class and justifying their decision. Individual students quickly suggest why the remaining two suggestions should be discarded: Sally asks them to try again to think of an appropriate equation. Having circulated the room monitoring the work of students on their mini-whiteboards Sally is just about to move on when a student suggests he has a possible solution, $2y = x^2 + 4$, which as soon as he suggests to the class he dismisses. There is a comfortable atmosphere in the room as students are very willing to make mathematical suggestions and expect their peers to comment on the validity of the statements they make.

Sally now, controlling the mathematical narrative, shifts the students' attention asking them to consider her next "picture" which shows graphs of $y = x^2$ and $y = (x – 1)^2$ displayed on the same set of axes. She draws attention to the fact that the original $y = x^2$ passes through the point (2, 4), marking this clearly on the board and asks "whereabouts is that 4 (pointing to the vertical line segment she has drawn) on the graph that has moved across one?" A student responds by pointing out that it has moved across to $x = 3$. Sally points out that, "to get $y = 4$ when $x = 3$ you don't square the three but square the two". She now asks what happens when the graph is moved another one unit horizontally, and returns to the previous picture. One student suggests $y = x^2 – 4x + 4$ and, after recording this, Sally quickly sweeps the room and identifies that a number are suggesting $y = (x – 2)^2$ by writing this equation on their mini-whiteboards. Again this latter suggestion is checked using the original points that it must satisfy. The group quickly determines that this is a suitable equation. Sally's suggestion of checking the former of the two suggestions is rebuffed by a student who says that it is the same, explaining that multiplying out the brackets in the "completed square" version leads to $y = x^2 – 4x + 4$. Sally now asks students to give a possible equation for the graph she had used to prompt the current line of thinking (i.e. the graph of $y = (x – 1)^2$). Many of the students quickly suggest the correct equation and once again this is verified by examining some points that lie on the graph. One of the students, at this point, tries to explain why this is the equation: this attempt comes without prompting from Sally. Recognising that this is a difficult idea, particularly to articulate, she asks one or two others if they understand and if so to explain in their words. After a number have done so, one student asks if the graph of $y = x^2$ is moved one place to the left "should one be added on in the brackets". It is significant that this was going to be the next area of exploration suggested by Sally: she is able to bring up a ready drawn graph of the situation which she now asks students to consider by again checking whether points on the graph satisfy the equation. Here the control that Sally maintains over the mathematical narrative of the lesson is brought to the surface by the very fact that although a student appears to suggest the next logical line of enquiry it is clear that they have been carefully led to this by Sally's unfolding story about the mathematics. Perhaps, as might be expected, students are asked to explain why one needs to be added to the x before it is squared.

Sally moves on to ask students to write on their mini-whiteboards a possible equation for a quadratic which touches the x- axis and has a positive intercept on the y-axis but where neither axis is scaled: she demands that everyone on a table has a different possible equation. Following a public display, Sally writes three suggestions on the board, $y= (x – 3)^2$, $y= (x – 7)^2$, $y= (x – 4)^2$: she asks a student to explain whether or not he considers these correct and to explain why the number in the bracket is subtracted from x. Due to space restriction here we must leave further description of a lengthy teaching sequence spread over some two hours.

ANALYSIS AND DISCUSSION

This extract of just part of one of Sally's lessons exemplifies how central she is in orchestrating her student-centred classroom. The lesson contrasts markedly with many we have observed in case study colleges where the teacher, whilst equally central, relies on a transmission mode of teaching, telling students key results followed by them working through carefully graded exercises and eventually practising the types of questions they will meet in terminal assessment. The whole-class is almost always socially involved in the development of the mathematical narrative in Sally's lessons: this is fundamental in her planning of lessons, as our follow-up interviews have determined. In her planning it is the mathematics that takes the lead, as she considers, "why, what are the problems, what are the difficulties, what do they [students] need to know, what are the issues?" The mathematical narrative of Sally's lessons is determined by her consideration of these key questions whilst the social narrative which is reflected in the practices she uses to engage her students is subservient to this: having decided on the key features of her mathematics she brings together mathematical and pedagogic content knowledge to devise activities with which she provides a guided re-invention of the mathematics at issue, in the sense of Freudenthal and colleagues (e.g. Treffers, 1987).

We consider that there is a contradiction, then, between the lesson being 'student-centred' in some activity and 'teacher centred' at other times, with these different phases having different objects and being differently mediated. When Sally engages students in social participation (eg group work, making posters etc) she is working with their ideas, (mathematical and intuitive) and ensures that their agency is given expression. Her own role is one of monitoring / assessing and so on. She facilitates students in their attempts to solve problems or create explanations 'in their own words', although they may be adopting some of her mathematics too to the extent that they understand it. The *object* of such activity is the problem the students work on and it is understood that they are to 'have a go' with their own mathematical tools/concepts.

However, central to Sally's teaching are episodes when she takes control of the key elements of the emerging mathematical narrative, when her students' misconceptions are addressed. Sally interweaves this narrative with the students' own mathematical productions as they emerge from their 'sociable' activity: however, she subtly ensures that priority is given in such episodes to the 'correct', or more advanced mathematics that she wants them to understand, and of which she is pretty much the arbiter/judge. The *object* of this activity, then, is effectively to construct some sense of the 'more advanced mathematics' of which Sally is the key mediator.

The contradiction between the lesson being 'student-centred' in some activity and 'teacher centred' in other activity is explained by considering that these episodes have different objects and are differently mediated. The contradiction can be considered to be resolved when – through practice – the object of the teacher-centred activity (the new mathematics to be learnt) has become operationalised by the students as a mediating tool in their own student-centered activity. What one sees when the students begin to play a substantial part in the teacher-centred activity (eg when the students begin to take over the work from Sally) is the beginning of this process. On the other hand this progression also continues as Sally withdraws her pedagogic mediation during student-centred activity (due to lack of space we have been unable to describe later episodes here where this is more evident). This process of operationalisation (or what Leont'ev called automisation) often concludes in Sally's case with the students being required to write their own notes or poster of what they have learnt, eg with examples of the new mathematics.

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