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ABSTRACT

This article explores factors influencing the teaching approaches of mathematics teachers new to the profession. I argue that the most significant influence on teaching approaches in England is the dominant discourse of school mathematics, which is affected in turn by recent changes in educational policy and the associated increase in performativity in schools. This discourse fosters teaching pedagogies and practices which are contrary to those promoted by most teacher educators and serve to reproduce alienation and inequities within mathematics classrooms. I make use of a series of semi-structured interviews, carried out with colleagues in a school in which I was teaching at the time, to inform this theoretical discussion. I conclude that the current discourse of school mathematics is open to change for the better but that this will only occur if teacher educators engage with experienced teachers of mathematics, particularly those acting as mentors to trainee teachers.

Introduction

> 'Don't ask me to think up my own question! Just give me a question and I'll answer it!' (Vicki (2010))

This was the agitated response of a student in a Year 11 mathematics group, which I had recently taken over, at Parkside School (a pseudonym). I had just shown the class a distance-time graph, representing my journey to school by bike, and had asked students to devise their own questions,

which could be posed in order to better understand the shape and meaning of the graph. What was it that made her so agitated? Was it that I had asked her something that was beyond her capability? Could it have been that I had challenged her perceptions and beliefs about the correct way to learn mathematics?

Posing her own problems was maybe not something she wanted, or expected, to do, perhaps suggesting a preference for a more traditional 'transmission model' style of teaching. It may be the case that this was based on a belief that mathematics is more about answering than posing questions, illustrative of 'popular understandings of mathematics as an unquestionable certain body of knowledge' (Ernest, 2004: 16). Perhaps the emotional response was down to the General Certificate of Secondary Education (GCSE) mathematics terminal papers to be taken in less than a year's time, with so much at stake and a concern that my less familiar teaching methods were not the best way to help her prepare for these.

Unfortunately, Vicki's response demonstrates the predominance in mathematics lessons in England of a teaching pedagogy based on developing factual recall and procedural understanding with little relevance to life outside of the classroom (Boaler, 2009). Nardi and Steward (2003: 345) describe the 'quiet disaffection' of a large number of students from mathematics as a result of such pedagogies which they characterize as promoting 'Tedium, Isolation, Rote learning (rule-and-cue following), Elitism and Depersonalisation'. This is particularly true for students from disadvantaged backgrounds who are often provided with an inferior curriculum, designed to prepare them for low-status employment, thus reproducing inequities within society.

This is a frustrating situation for mathematics teacher educators, among whom there is a broad consensus in favour of a 'pedagogy of investigation' (Gates, 2006). When I undertook my initial teacher training in the mid-1980s, there was a clear promotion of teaching in a creative, engaging, inclusive, collaborative way, focussing on conceptual rather than instrumental understanding and promoting equal opportunities for all students. From my experience this is still the message that is communicated to most trainees undertaking initial teacher education courses. So why, despite the efforts of teacher educators, does this transmission style of teaching mathematics persist? After all, the initial teacher trainees of today are likely to have been taught themselves by teachers who trained in the mid-1980s or later. So why has nothing changed?

The Position of Mathematics in School and Society

Mathematics occupies a privileged position within a school curriculum in England which is dominated by high-stakes assessment. Together with English, GCSE mathematics results are used to measure the relative success of schools in an education system in which performance increasingly determines a school's ability to attract applicants and accompanying resources. This high-status nature has been attributed to a questionable belief that mathematics serves as a valid measure of general intellectual ability (Ernest, 2004). This is based on a misguided assumption that mathematics is a value-free subject which provides a reliable measure of intelligence:

> Mathematics has stood as exemplar of truth and rationality since ancient times, giving it a unique status in most world cultures and intellectual communities. That status may account for mathematics being seen as a marker of general intellectual capacity rather than simply aptitude in mathematics. (Lerman, 2000: 21)

Historically, mathematics has been viewed as a neutral, value-free subject, 'dominated by an absolutist paradigm, which views it as a body of infallible and objective truth, far removed from the affairs and values of humanity' (Ernest, 1991: xi). This view is increasingly being challenged by philosophers and mathematicians who are 'affirming that mathematics is fallible, changing, and like any other body of knowledge, the product of human inventiveness' (ibid.: xi).

However, Wiliam (2003) argues that, far from being value-free, the form of assessment that is used in schools is dependent upon a particular conceptualization of mathematics. School mathematics, he argues, has been constructed in such a way that it creates artificial differences in achievement, for example 'our definitions of mathematics are precisely those that keep males outperforming females' (ibid.: 201). Thus it makes little sense to talk of performance in school mathematics as being a good indicator of general intellectual ability.

Justifiably or not, mathematics functions as a 'critical filter', with success in school mathematics providing much higher levels of access to further education and employment opportunities (Black et al., 2009). The high-stakes nature of mathematics assessment helps to explain particularly high levels of alienation from the subject through the promotion of mathematics pedagogies based on 'teaching to the test' and instrumental learning, rather than developing deeper understanding:

> The current high-stakes assessment system, where institutions are more accountable for results than for the mathematical understanding of their students, has a detrimental effect on the ability of young people to apply mathematics . . . some areas of mathematics which are more difficult to assess, such as problem-solving, reasoning and communication, are not given sufficient teaching time and are often replaced in the classroom by teaching routines and procedures necessary to pass the test. (ACME, 2011: 3)

The focus on factual recall and procedural understanding encourages the perpetuation of a 'traditional' school mathematics curriculum considered to be 'boring, irrelevant, and meaningless, by adults and children alike' (Mukhopadhyay and Greer, 2008: 170).

The critical filter role occupied by mathematics serves to reinforce inequities within society with lower levels of participation of some groups, for example ethnic minority students and girls, in post-compulsory mathematics (Black et al., 2009). Children from certain groups, particularly higher-income white males, are more predisposed to succeed in mathematics, as they are in other subjects, despite any efforts made by schools to provide a level playing field for all students. This is attributed to a Bourdieusian notion of 'cultural capital', that is, an awareness of how to 'play the game' and develop behaviours and attitudes that are expected and valued by teachers. Such 'cultural capital' is more common among middle-class students: 'So only those children who come already endowed with such capital are in a position to make the most of the opportunities schools purport to "offer" equitably to all children' (Noyes, 2008: 55). In this way mathematics plays a key role in reproducing inequities within society:

> Often with a psychological brutality that nothing can attenuate, the school institution lays down its final judgements and its verdicts, from which there is no appeal, ranking all students in a unique hierarchy of all forms of excellence, nowadays dominated by a single discipline, mathematics. (Bourdieu, 1998, cited in Noyes, 2008: 52)

The Rise of Performativity and New Right Ideologies

There has been significant recent criticism of educational research, particularly in the United States and Britain, suggesting that much of it is of poor quality, lacks practical relevance and is inaccessible to practitioners in schools (Gough, 2004). It is claimed that, as a result, teachers do not take

enough notice of research findings, preferring to rely on their own professional knowledge based on what works from their own experience. Out of a desire to incorporate research evidence with the professional knowledge of the teacher, the evidence-based practice movement has grown (Thomas, 2004). At first sight, the phrase 'evidence-based practice' is something that seems self-evidently beneficial. The assertion that 'practice would be improved if practitioners were more familiar with the results of research' (Hammersley, 2004: 134) seems incontrovertible.

However, critics of the evidenced-based practice movement claim that it has been accompanied by an undermining of teachers' professionalism. Hammersley (2004: 143) describes how 'criticism of the public sector for failing to "deliver" a satisfactory level of service' led to the widespread adoption in the 1970s and 1980s of management practices from the private sector. Demands for 'public accountability', endorsed by both major political parties, also contributed towards the introduction of objective performance indicators 'that would allow politicians and the general public to judge what was happening and whether it could be improved' (ibid.: 142).

Systematic reviews of research in a particular field, favoured by successive governments as the primary means of promoting evidence-based practice, involve some teachers and other practitioners participating in advisory groups, setting the review questions and refining the review's scope (EPPI, 2007). However, rather than making research more accessible to practitioners, systematic reviews can be seen as a way of deciding on practitioners' behalf what works, which is then used to set targets against which teachers' performance is measured. The majority of teachers are then expected to implement without question the recommendations for changes in practices that policy-makers believe are necessary to achieve these targets (Hammersley, 2004).

My experience from working in and visiting a wide range of schools over recent years is that teachers are being exposed to ever-increasing levels of scrutiny with more and more regular observations by managers of their classroom practice, many of these with little or no notice. Observations are linked to targets and criteria for effective classroom practice, determined largely by Ofsted measures, with teachers being graded according to the extent to which these are met. Thus, teachers are susceptible to Foucault's notion of 'governability', as regulation becomes less and less necessary as teachers increasingly, and often subconsciously, begin to regulate themselves.

A drift towards a New Right ideology has led to education policies, particularly in mathematics education, which have contributed towards the alienation of many learners and increases in inequities highlighted above. The publication of *Mathematics Counts* (Cockcroft, 1982), which rejected a reliance on rote learning while promoting problem-solving, discussion, groupwork and the use of computers and calculators as mathematical tools, illustrated the dominance up until the mid-1980s of progressive and utilitarian ideologies of mathematics education (Ernest, 1991). The subsequent rise of a 'New Right' political ideology resulted in a 'back to basics' agenda, with an emphasis on improving basic number skills through a transmission model of teaching, the promotion of selection and increased marketization in schools (Ernest, 1991). The introduction of the National Curriculum (DES, 1989) established an assessment-driven curriculum based on traditional subject boundaries and discrete items of mathematical knowledge and skills. This was accompanied by the introduction of national tests at age seven, eleven and fourteen and the publishing of performance league tables. While the National Curriculum steered clear of dictating pedagogical approaches, the National Numeracy Strategy and the Key Stage 3 National Strategies (DfEE, 1999, 2001) promoted a focus on whole-class teaching and recall of facts and procedures.

These policies, combined with the increased pressure on teachers through performance management to put such policies into practice, has led to the maintenance of traditional approaches to teaching mathematics, despite attempts by teacher educators to promote alternative pedagogies:

> Too much time is spent developing fluency in recalling facts and performing skills . . . much greater emphasis should be placed on . . . conceptual understanding and interpretations and representations and strategies for investigation and problem-solving. (NCETM, 2008: 3)

The Dominant Discourse of School Mathematics

A dominant discourse of school mathematics has developed in England that promotes certain practices, such as viewing mathematics as a hierarchical subject and setting students by ability, as a natural state of affairs. Shaw (2009: 90) describes how the school mathematics curriculum is characterized by an 'un-negotiable sense of being right or wrong, of being a success or a failure, of life or death, and of there being nothing in between'. It is seen as prescriptive and hierarchical: 'mathematics does seem closer than

most other subjects to an older, more disciplinarian model of teaching and learning which featured rote learning' (ibid., p. 90).

Hardy (2004: 106) describes how Foucault's notion of discursive practices as regulatory and self-regulatory can be used to explain how these practices 'masquerade as "common sense" without any evidence on which to base such assumptions. Setting is a prime example where research studies show little difference in outcomes however grouping by "ability" is central to official discourse, in spite of the lack – well known to [the DCSF] – of supporting research evidence' (Winbourne, 2009: 63). Setting by ability has been shown to demonstrate a close correlation with gender, class and ethnicity (Black et al., 2009).

This discourse around ability in mathematics education includes a strong assumption that 'students with different levels of "ability" require differentiated curricula' (Morgan, 2009: 104) with lower-attaining students receiving 'a largely remedial (and boring) curriculum' (Hodgen and Marks, 2009: 31). This discourse can be traced back to the late 1980s. Dowling (1990) describes how the National Curriculum, and other associated reforms, compounded the situation in schools where less able students (predominantly working class) were provided with a 'mundane' curriculum focussed around mathematics in everyday life, while the more able students (predominantly middle class) were provided with a more 'exotic' curriculum focussed around mathematics in academic life. Brown (1999) describes how almost all students in England are placed in ability sets by the age of twelve, with higher sets being offered more abstract mathematics and lower sets more mathematics for everyday life. The idea of two parallel curricula, with 'lower-ability' students following a more functional approach to learning mathematics, is reflected in the new GCSE mathematics syllabus introduced in 2010. Under the new specifications, between 20 per cent and 30 per cent of the questions on the Higher Tier, targeting students from grades A* to C, will assess the functional elements of mathematics, whereas the corresponding figures for the Foundation Tier, targeting students from grades D to G, are between 30 per cent and 40 per cent (Edexcel, 2009).

Interviews with Colleagues

The dominant discourse in school mathematics in England provides the context for a series of interviews I carried out with colleagues in Parkside

School, in which I was teaching at the time. The school was a large urban 11–18 mixed comprehensive school with below-average, but improving, attainment at GCSE. The school had experienced a recent high turnover of staff and had a high proportion of relatively inexperienced teachers within the mathematics department. My interest in conducting this research was stimulated by Ernest's claims (1991) that epistemological beliefs, particularly the adoption of absolutist or fallibilist views, have a direct impact on ideologies of mathematics teaching which, in turn, lead to the favouring and promotion of particular approaches to teaching mathematics. With this in mind I set out to explore the link between teachers' views of mathematics and their preferred teaching approaches.

The aim of my research was to seek to understand teachers' views, rather than to explain their observed behaviour, and I considered it important to give consideration to my own position as insider researcher. I therefore chose to adopt an 'empathetic approach' towards carrying out unstructured interviews based upon an understanding of, and sensitivity towards, the positions of power between myself as interviewer and the interviewees (Fontana and Frey, 2008). My research question was: 'To what extent do teachers' views of mathematics influence their teaching approaches?'

I selected three members of the mathematics department, Rob, Andy and John (pseudonyms), largely through convenience sampling. All three were at an early stage of their teaching careers and had studied a subject other than mathematics at degree level. The sample was not meant to be representative of mathematics teachers in general, although non-subject specialists and less experienced teachers are relatively common among mathematics teachers, particularly in schools with a high staff turnover such as Parkside.

I conducted two interviews with each participant, using open-ended questions designed to promote dialogue, focussed on participants' views of the nature of mathematics, their approaches to teaching mathematics and their perception of the main influences on these approaches. A full analysis of interviews, using both audio-taped recordings and transcripts, focussed on identifying themes and communicating the meaning of participants' responses in relation to the research question. The main method of analysis used for the interviews was 'meaning condensation' and 'meaning interpretation' (Kvale and Brinkmann, 2009). This involved summarizing participants' responses, interrogating these in relation to the main research focus, describing themes which emerged from the analysis, and identifying the meanings behind these which might not be immediately apparent.

Analysis of Interviews

Participants demonstrated in their responses significantly different, if somewhat complex, epistemologies of mathematics. When asked the extent to which he agreed with the statement 'mathematics is based upon unquestionable truths', Andy described this as 'a concept that we can buy into and I guess I would bet everything on it'. This, together with other responses, suggested a primarily absolutist view of mathematics. In contrast, Rob's response to the same statement was 'I'd say I'd generally disagree', which he justified using an example of where a mathematical statement might be true or false dependent upon the context or situation. This, together with other responses, suggested a primarily fallibilist view of mathematics. John's response was to agree with the statement in some respects but to disagree in others, suggesting a partially absolutist and partially fallibilist view of mathematics: 'There are many ways to go around solving a problem but you may well use unquestionable rules and things you can't change.'

In contrast, all three participants demonstrated a similar ideology of mathematics education and agreed on the desirability of a problem-solving approach to teaching. There was a strong belief among all three in the importance of functional mathematics teaching and preparing students for solving problems in the workplace. When asked 'What do you think should be the main aims of mathematics education?', they responded:

> Being numerate with numbers. It's important to be able to function in a world which does depend on numbers . . . then to be able to extend and push kids into being, at the end of the day, employable. (Andy)

> The aim for all kids should be to come out with a functional level of maths . . . so that, in their day-to-day life and in a lot of jobs, they could deal with problems. (Rob)

> I see maths as all about getting a problem, and using your knowledge to solve that problem . . . when you get a problem in real life that's not mathematical as such, your brain is more able to cope with solving that problem than it would have been otherwise. (John)

The most striking similarity in participants' beliefs about mathematics education was their unanimous assertion that mathematics teaching approaches should be distinct for students of different abilities. All three argued that 'lower-ability' students should be provided with a more functional curriculum, while only 'higher-ability' students should be provided

with opportunities to develop their mathematical thinking through abstract concepts and problems. For example, when asked how he would change the current school mathematics curriculum, Andy replied:

> I would change it . . . to differentiate between kids who . . . really enjoy it as a subject, and really value it, and want to get a pure element out of it . . . Essentially, a lot of kids doing a Foundation GCSE, it would be better to do what I would say, we are calling it functional skills maths now.

Such a view, with distinct aims for teaching mathematics to 'lower-' and 'higher-ability' students, would appear to be consistent with the dominant discourse of mathematics education described above.

All three participants described being taught in a relatively formal way at school, based typically on working from textbooks, and all three described these experiences as positive. When asked to reflect on the extent to which their own school experiences influenced their current teaching approach, all three agreed that this was significant, but in a variety of ways. Andy felt the most comfortable with the way he was taught whereas Rob's response was quite different as he initially reacted to the way he was taught at school, based on what he perceived to be its shortcomings. John, despite his success at school, had more recently begun to question how relevant some of these teaching methods were towards his own teaching. At the same time, he felt reluctant to dismiss the way he was taught completely.

When asked about the biggest influences on their approaches to teaching, all three participants agreed that this had been observing, working with, and being guided by other teachers. This is typified by Andy's response: 'I'd say it's seeing other teachers teach . . . taking knowledge from that . . . adapting it, or trying it . . . the thing that influences me more than, for example, a meeting or talking to someone, is actually seeing lessons.'

When participants were asked to say more about their experiences of initial teacher education, the consensus was that their experience in placement schools, particularly the relationship with the school-based mentor, had played a vital role in the development of their teaching approaches. This was in marked contrast to the influence of the university-based element of the course which was described, for example, as 'a bit irrelevant' (Rob) and 'frustrating' (John).

Discussion

While exhibiting very different views of mathematics, all three participants appear to share common beliefs about desirable teaching approaches and the aims of mathematics education. This seems to conflict with Ernest's claim (1991) that epistemologies of mathematics are one of the most significant influences on teaching approaches. The participants concur that the most significant influence on their own teaching approaches is observing, working with and trying out the ideas of other teachers, particularly those acting in a mentor role. Since all three participants teach in the same school, which is the only school they have taught in as qualified teachers, this might explain why they share similar beliefs about mathematics education, that is, their beliefs are constructed from the dominant discourse within the department.

It is clear that the influence of colleagues, particularly mentors, in schools is significantly greater than that exerted by the university-based element of initial teacher training. This helps to explain why the dominant discourse of school mathematics has such a large effect in maintaining the dominance of transmission-style teaching approaches in many mathematics classes despite the best efforts of teacher educators. The influence of participants' own experiences of learning mathematics on their teaching approaches suggests another factor that discourages changes in mathematics pedagogies. This relates to Bourdieu's notion of 'habitus', which explains how teachers are subconsciously influenced by their own schooling: 'We are all prisoners of our past and act according to various social norms and consequently develop enduring dispositions' (Gates, 2006: 352).

The effect of the dominant discourse of school mathematics on participants' beliefs is also evident in the common advocacy of two separate mathematics curricula, one for 'lower-ability' students based on a utilitarian ideology, and one for 'higher-ability' students based on a more progressive ideology. This is of particular concern to those, such as myself, who because of concerns over issues of equity advocate an entitlement to one mathematics curriculum for all, with 'a single ladder of coherent and rigorous qualifications, where differentiation is only by level of knowledge and is not determined by the other courses a student is following' (Brown, 1999: 88).

It is interesting to note that when asked to list significant influences on their teaching approaches, none of the participants suggested the high-stakes nature of mathematics assessment or the pressure from performance

management, although when these were put to them specifically, they accepted that they had some influence. The unquestioning acceptance of an assessment-driven curriculum and focus on performativity might suggest that these have been become accepted 'regimes of truth' as part of the current discourse of school mathematics.

Conclusion

Contrary to expectations, I found that teachers' epistemologies of mathematics have much less influence on teaching approaches than the dominant discourse of school mathematics. This suggests that a focus, as part of initial teacher education, solely on exploring the nature of mathematics and developing collaborative, engaging, problem-solving pedagogies, will continue to have little long-term impact upon mathematics teaching in schools. While this may succeed in producing trainee teachers who, in the short term, adopt more progressive teaching approaches, these successes will be short-lived as teachers new to the profession come under increasing pressure to conform to the practices fostered by the dominant discourse of school mathematics.

The message is clear that those wishing to change currently ascendant teaching pedagogies and practices in mathematics classrooms should pay particular regard to this discourse and to the influence of experienced teachers, particularly those acting in a mentoring capacity, on less experienced mathematics teachers. Engagement by teacher educators with school-based mentors is therefore critical in enabling new teachers to continue to evolve the teaching approaches they develop during initial teacher education courses and to empower these teachers to have a positive and enduring impact on the pedagogies of the departments in which they are working.

Teacher educators who wish to affect positive changes in mathematics pedagogy through their work with student teachers should also engage in research that involves working collaboratively with qualified teachers. Torrance (2004) proposes an alternative model of evidence-based practice centred on action research in which academics provide initial input, based on previous research, support teachers in their use of research methods, and are responsible for reporting the findings. Through investigating and reflecting on their own practice, this model has the potential for teachers to generate research data which is 'crucial to developing an understanding

of theory-in-practice' (ibid.: 199) while, at the same time, challenging the dominant discourse of school mathematics. As a teacher educator myself, I appreciate how difficult this is to achieve, as teachers find it increasingly difficult to commit the time and energy required for such engagement due to pressures of performance and accountability.

However, I contend that the current discourse of school mathematics is not set in stone and is liable to change over time (as it has changed since I began teaching in the 1980s). Nor is the dominant discourse described in this study, which represents the situation currently in England, universal. In France, for example, the notion of separate mathematics curricula would conflict with the dominant discourse of school mathematics which is based on promoting comprehensive education and an 'entitlement' of all students to the same mathematics curriculum (Pepin, 2009). As teacher educators, we have a responsibility to do everything in our power to transform the discourse of school mathematics in England into one which promotes equity and social justice. This might make it possible in the not too distant future to break the link between school mathematics and high-stakes assessment, thus enabling a more engaging, relevant and inclusive school curriculum, based on problem solving, collaborative learning and mathematical inquiry, to flourish.

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