Discerning the Shared Beliefs of Teachers in a Secondary School Mathematics Department

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This study examined the shared beliefs among mathematics teachers in one secondary school in the United Kingdom across the first term of a school year and almost 4 years subsequently. Leximancer software was used to analyse the language used as teachers responded to questions concerning their beliefs about mathematics, mathematics teaching, mathematics learning, and their department on at least two occasions. The analysis revealed changes of language and evidence of shared beliefs at each point in the study.

The value of collaboration among teachers as they learn about mathematics teaching (McMaster & Cavanagh, 2015), plan for mathematics teaching (Sullivan, Clarke, Clarke, Farrell, & Gerrard, 2013), and seek to improve their practice (Ell & Meisell, 2011) has been recognised. Indeed, collective participation in professional learning (PL) activities by teachers from the same school, year level or subject has been identified as a feature of quality PL (e.g., Garet, Porter, Desimone, Birman, & Yoon, 2001; Schleicher, 2016). There is also recognition that mathematics teachers' beliefs about such things as the discipline, mathematics teaching and learning, their role as teacher, and their students' capacity to learn mathematics influence their teaching (e.g., Beswick, 2005; Bray, 2011; Speer, 2008). Researchers have documented changes in teachers' beliefs as they work to establish collaborative practices in their mathematics classrooms (e.g., Boaler 1999; Hunter, 2010) sometimes supported by collaboration with colleagues and researchers (e.g., Hunter, 2010). There appears, however, to have been little attention paid to the shared beliefs of groups of teachers working together and how these might develop. An exception is a study reported by Beswick, Watson and DeGeest (2007; 2010) that drew on some of the data that formed the basis of the current study. The focus of the current study is on the shared beliefs of a group of teachers working together within the mathematics department of a single school, inferred from an analysis of the language used by participants over time. It addresses the research questions:

1. What shared beliefs about mathematics and mathematics teaching and learning are evident from the language of teachers across a school term and several years later?
2. How might the results of analysis using Leximancer software contribute to the identification of shared beliefs?

The study sheds light on how mathematics teaching at the school level rather than individual teacher level might be influenced, and supports the importance of collective participation in PL by mathematics teachers from the same school.

Inferring teachers' shared beliefs

Individual teachers' beliefs, taken to mean anything that the teacher regards as true (Beswick, 2005), have been inferred from their responses to Likert type survey items (e.g., Beswick, 2005), scenarios constructed to elicit specific beliefs (e.g., Ambrose, Clement, Philipp, & Chauvot, 2004), and responses to items designed to reveal respondents' pedagogical content knowledge (Beswick, 2015). Beswick (2015) found that when a pre-

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service teacher talked about the relative merits of four representations of a proportional reasoning task his answers comprised mainly belief statements from which several broader underpinning beliefs could be inferred. The current study set out to test the extent to which a similar approach might be an effective way to explore the beliefs of a group of teachers.

The reasonableness of inquiring about the beliefs of a group rather than of an individual can be argued from the tenets of complexity theory. Complex systems, such as flocks of birds flying in formation, have properties that transcend the individuals that comprise the system (Davis & Simmt, 2003). Davis and Simmt (2003) argued, therefore, that it makes sense to talk about such systems, including classes of students, in anthropomorphic terms: teachers routinely refer to 'good' and 'challenging' classes. The beliefs of a group of teachers might be considered as contributing to the ethos of the department they comprise, not belonging to particular individuals but emerging from their interactions and guiding the actions of the group in much the same way that an individual teacher's beliefs influence his/her behaviour.

The Study

The study was conducted in two parts in one comprehensive English secondary school. The first part of the study occurred across the first term of a school year in which the mathematics department had undergone a significant change of staff including the arrival of a new Head of Department (HoD). The second part of the study occurred approximately 4 years later and was designed as a follow up to the first. The school had specialist mathematics status and hence the HoD had additional responsibilities for teacher development, community engagement, and dissemination of good practice.

Initial findings from the first part of the study were described by Beswick, Watson and DeGeest (2007; 2010) in the context of comparing the efficacy of activity theory and complexity theory in analysing change in school mathematics departments. Beswick et al. (2010, p. 163) identified the following emergent phenomena:

- an increasingly shared understanding of the meaning and importance of mathematical thinking in improving students' attainment
- consensus around the idea of providing access to higher levels of attainment for all students
- a long term view of improving attainment
- a shared sense that the department was supportive.

The current study provides a more detailed analysis of individual interview data from the entire study including the 4 year follow up interviews. It focuses on the teachers' language and what it might reveal about their beliefs as a group as well as the efficacy of the software, Leximancer, for assisting in identifying collective beliefs.

Participants

Participants were all ten mathematics teachers in one school during the first term of the 2006/07 school year, and seven teachers at the end of the second school term of the 2009/10 school year. The original ten teachers included four who were just starting at the school. These comprised two newly qualified teachers (NQTs), an experienced teacher taking on a management role in relation to lower secondary mathematics in the school, and the HoD. The six teachers interviewed 4 years later comprised all but one (an NQT) of the teachers who had been new to school in the original study, three other teachers who had

participated in the original study, and one teacher who had joined the school subsequent to the original study. Six teachers, therefore, contributed data at the beginning and end of the 4 year period.

Instrument and procedures

Data comprised ten individual, semi-structured interviews of approximately 1 hour, conducted at the beginning and end of the first 2006/07 school term. Further interviews were conducted in the middle of that term with four participants – the HoD, one NQT, the new experienced teacher, and a continuing experienced teacher. Finally, seven individual interviews were conducted at the end of the second 2009/10 school term. For all but NQTs, 12 of 15 questions were common to all interviews. These questions are shown in Figure 1. Changes for the NQTs were minor. For example, Q7 was replaced with "How would you describe your first few weeks at <name of school>?" and Q9 was replaced with, "Tell me about any particular people, materials or processes that have helped you to settle in to the school? What have you found valuable about each of these?". All 15 questions were included in the Leximancer analysis. Interviewer contributions were not included.

2. What do you enjoy most about teaching mathematics? Why? Has this changed over time? Why?
3. What do you enjoy least? Has this changed over time? Why?
4. Describe an ideal mathematics lesson. What would the students be doing? What would you be doing? How does this compare with reality? Why is reality different?
5. How would you describe your overall aim in teaching mathematics? Is this the same for all of your classes? For all year levels/sets? To what extent do you feel you will be able to achieve this/these aims here? Why? Has this changed over time? Why?
6. To what extent do you think your colleagues share this/these aims? What makes you think so?
7. How would you describe your time in the department over the last few years?
8. What has been the best thing about teaching here?
9. Are there any particular people, materials or processes that are particularly supportive of your work?
10. In what ways do you think that you have influenced the ways in which maths is taught here? The way that the department operates? How/why do you think this happened?
12. How well do you feel that your ideas about maths teaching fit in with what has been happening at this school/department? Has this changed over time? Why?
13. In what ways do you think the department has changed since 2006? Why do you think so?
14. Are/will you be comfortable with these changes? Why/why not?

Figure 1. Common interview questions.

Leximancer software has been found to yield results comparable to those obtained using manual thematic analysis (e.g., Grech, Horberry & Smith, 2002). In the current study it was used to identify concepts in the interview transcripts at each point in time at which interviews were conducted. Concepts are defined as collections of words that related to a central theme. These themes are developed through an iterative process of merging concepts based on semantic overlap (e.g., teachers, teacher, staff) and the exclusion of concepts based on inadequate specificity.

The analyses were conducted and results summarised under instruction from but independently of the author. This ensured that the summaries were not influenced by the author's prior knowledge of participants and of the data. The summaries were then examined in relation to extracts of transcripts that related to them, modified in some cases where the researcher's contextual knowledge was crucial to interpretation. Lists of beliefs were inferred from the summaries of each of the four sets of interviews in a process similar to that used by Beswick (2015) for the transcript of an individual interview.

Results

The results are presented in relation to each set of interviews in the sections that follow. In each case the themes identified are listed (in italics) along with their connectivity which is indicative of the connectedness of concepts within a theme and hence the importance of the theme. The most important theme is assigned a connectivity of 100% with the connectivity of other themes calculated in relation to that. The concepts that contributed to each theme are also provided along with the number of times (in parentheses) that each concept occurred in the total text of the interview transcripts. In suggesting possible shared beliefs greater weight was given to the most important themes (i.e. those with greatest connectivity) as these were likely to have been referred to by several teachers.

Initial interviews

The themes that emerged from the initial interviews were: *work* (100%; concepts: work (86), time (47), lesson (44), learn (35), use (28), class (24)); *teaching* (97%; concepts: teaching (96), mathematics (87), people (55), department (32)); *year* (58%; concepts: year (76), group (46), level (30)); and *teacher* (58%; concepts: school (50), teacher (43), term (34), idea (33)).

In the initial interviews participants focused on the theme of work in terms of the external pressures to get good results (league tables), working with a range of students (gifted vs. others) and the tasks that were appropriate for differing groups, working in differing schools and in team settings, reviewing the work from previous lessons, students working in differing ways with common ideas, and students of differing ability levels working with a common mathematical structure. Participants focused on the theme of teaching in terms of time spent teaching, the departmental head's attitude (positive), the variable quality of teaching by different teachers, and the matters discussed at departmental meetings. They focused on the theme of year in terms of the immense future value of present difficulties, coming back to teaching with 17 years of experience, dealing with groups in differing year levels, and the likely value of a two-tier examination for students. Participants focused on the theme of teacher in terms of needing to talk to more students and teachers to get a sense of what was happening in the department, a perceived need to attain objective outcomes both as a school and as teachers, sharing ideas for good practice

including by observing others teaching, and the need ongoing effort to achieve consistency given the range of different teaching approaches.

Responses to the initial interviews tended to focus on broad issues and challenges of teaching as well as the demands of the external and school contexts in which the teachers worked. Beliefs that could be inferred from the foci of the teachers' discussion are:

1. We are obliged to aim for externally imposed objectives for student attainment
2. Ongoing effort is needed to achieve greater consistency of approach given the current diversity of approaches and variable teaching quality.
3. Students can work in different ways with the same mathematical structure.

Mid-term interviews

The themes that emerged from the mid-term interviews were: *year* (100%; concepts: work (61), class (58), year (52), use (47), group (31), level (27)); *time* (92%; concepts: teacher (58), time (56), teach (46), term (42), school (28), department (26)); and *people* (88%; concepts: people (77), mathematics (67), idea (56), lesson (41), learn (36)).

Participants focused on the theme of year in terms of wanting to teach particular classes through successive years to maximise their attainment, getting students in different year levels to make up examples, trying an approach that worked with very different classes, trying to get Year 11 students to add fractions using diagrams, a story about being a professional Sudoku player for couple of years told to a class to entertain them, and challenging students to aim for higher level examinations. They focused on the theme of time in terms of the difficulty of communicating the importance of mathematics when time is limited, the difficulties in using teaching time to best advantage, being concerned about whether new staff are getting sufficient support, having to think about where students are in their development of mathematics thinking, and as time goes on being less impressed by the HoD's management style and pressures to do more. Participants focused on the theme of people in terms of teachers thinking about teaching methods but not necessarily addressing student thinking, students having an elastic capacity to get things done including mathematics if it was of interest, people supporting one another, wanting students to like their lessons, and noting that a lot of conversations about learning were going on but being uncertain about the extent to which teachers were shifting their practice.

In summary, the mid-term interviews focussed more on specific matters including particular classes, examples from recent lessons, and concerns about the participants' own teaching as well as about colleagues and the department. Beliefs that appeared to underpin the teachers' responses are:

1. There are good teaching ideas that work well with a range of year and ability levels.
2. Teaching needs to address student thinking.
3. Time constraints mean that not everything that is desirable can be achieved.
4. Colleagues are discussing student learning but might not be changing their practice.
5. New staff need support – perhaps more than they are receiving.
6. The new HoD expects of a lot of staff.

End of term interviews

The themes that emerged from the end of term interviews were: *year* (100%; concepts: year (100), term (91), teach (87), work (80), time (78), class (77), group (51), level (26)); *mathematics* (61%; concepts: mathematics (113), lesson (77), teacher (76), school (55),

learn (39)); and *people* (30%; concepts: people (71), department (41), idea (37), use (33)).

Participants focused on the theme of year in terms of difficult students in particular year levels, the improvement in such students throughout the term, the effect of teaching more advanced topics on students' General Certificate of Secondary Education (GCSE) choices later on, longer-term colleagues compared with colleagues who were new that year, talking to a colleague because of his position as head of Year 9, the size of classes at differing year levels and in relation to ability groups, dealing with difficult behaviour in particular year levels, and the unwillingness of students in specific year levels to do more difficult work. They focused on the theme of mathematics in terms of being lucky because the students see the subject as more important than most (referring to the stigma attached to mathematics, English, and science), an ideal mathematics lesson as including lots of mathematical talk about what we can see, setting online mathematics homework to provide more flexibility in response to student home background differences, enjoying making progress in terms of student learning and interacting with colleagues about mathematics teaching. Participants focused on the theme of people in terms of being observed by people including interns, hearing snippets about how people teach certain subjects and a desire to share ideas, and people saying that the mathematics department is supportive.

The end of term interviews, like those at mid-term, focussed on particular classes and students but also on structural and policy issues at the school level that affect teaching (e.g., ability groups, class sizes, and homework), and ways in which teaching might be improved (i.e., classroom observations and sharing practice). Shared beliefs appeared to be:

1. Changes we're making now will give students more options at GCSE.
2. It's rewarding to see improvement in students who have been difficult.
3. Class sizes, behavioural issues and student attitudes all present challenges.
4. The department is supportive.

Four year interviews

The themes that emerged from the interviews conducted approximately 4 years from the beginning of the project were: *teaching* (100%; concepts: teach (78), teacher (78), year (67), time (61), work (56), group (52), people (50), mathematics (50), class (49), lesson (41), level (20)), *use* (17%; concepts: use (31), term (28), learn (26)); and *school* (11%; concepts: school (47), department (20), idea (19)).

Participants focused on the theme of teaching in terms of teaching load, non-teaching time, and time missed out of teaching during the year and the effect that has on teaching for the examinations. They also did so in terms of teaching experience (or lack of it), the point of teaching, aspects of teaching they disliked, the focus on mathematics, the difficulties in teaching merged classes of students with a broad range of abilities, the lack of time to repeat material and the sense that this pressure is also felt in other subjects. They focused on the theme of school in terms of the extent to which middle ability boys under-achieve in many schools, the need to justify trips or outings in terms of their contribution to learning, and the matter-of-fact nature of sharing ideas with others. Participants focused on the theme of use in terms of the need to go beyond teaching formulae, the need to make the material relevant beyond the exam, and the quality of results achieved by these methods.

As shown by the connectivity percentages, the theme, teaching, dominated the teachers' responses in the 4-year interviews. They focussed on the pressures imposed by examinations, other demands on school time, and mixed ability groups but also their desire to teach mathematics in meaningful ways in spite of these difficulties. Sharing teaching

ideas with colleagues was mentioned as a taken for granted practice. Beliefs that seemed to underpin the teachers' responses are:

1. Time is an important constraint in terms of workload and teaching material thoroughly.
2. School policies emphasise the importance of maximising subject learning time.
3. Maximising class time spent focussing on mathematics is a priority.
4. Having a wide range of abilities in a class presents difficulties for teaching.

Discussion and Conclusion

Looking across the four sets of interviews a shift is evident from broad contextual challenges in the initial interviews, to specifics related to their own teaching, classes and colleagues at mid-term. At the end of term the emphasis had shifted back to contextual issues but this time at the school level and broadly in relation to things that they were doing or could do to improve mathematics teaching in the school. After 4 years there was an emerging focus on teaching mathematics well and for purposes that included but went beyond examinations. In this context there was an emphasis on the pressures imposed by examinations and other school activities on the time that could be devoted to mathematics teaching.

Although it was possible to suggest beliefs that might be attributed to the department collectively the extent to which they were in fact shared is unclear. Ideally the analyses would be conducted iteratively and the suggested beliefs presented to respondents for comment as a way to establish the extent to which they were in fact shared. It is also not possible to discern any development in the beliefs across the period of the study.

The shifts noted across the sets of interviews and the differences between the sets of beliefs that appeared to be evident on each occasion could be attributed to the differing times of the school year at which they were conducted. That is, they may reflect the normal preoccupations and priorities of teachers at the start of a school year, in the middle of a term, at the end of a term, and the start of the second term of a school year. In spite of this there is likely also to be a component that is due to longer term and less cyclical changes such as NQTs becoming more comfortable in their roles, new teachers and the HoD settling into the school, and all of the teachers adjusting to the changed dynamics within the department. It is not possible to discern the relative impacts of these two phenomena.

The use of Leximancer allowed shared beliefs to be suggested in a way that was arguably less open to researcher preconceptions than traditional methods. As noted previously, the comparability of results from manual thematic coding and Leximancer analysis has been established (e.g., Grech et al., 2002) but it seems possible that a respondent could have a disproportionate effect on the outcomes of an analysis by producing a longer and perhaps more repetitive transcript. In this study the HoD interviews were substantially longer than those of other participants particularly in the end of term and 4-year interviews. An analysis excluding the HoD would make an interesting comparator.

The results of this study demonstrate the impact on the collective beliefs of teachers of school and external policy messages that are consistently communicated and for which teachers feel accountable. The degree of consistency between these messages and teachers' beliefs can contribute to teachers' happiness or otherwise with the policies concerned. In this study, for example, at the 4-year point teachers perceived considerable time pressure that conflicted with their beliefs about the importance of teaching mathematics thoroughly. The fact that mathematics teachers in a department appear to develop shared beliefs

underscores the importance of having multiple, ideally, all mathematics teachers from a school, attend PL together and be provided with opportunities to unpack and collaboratively apply their learning in the school context.

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