Applied Linguistics and Mathematics Education: More than Words and Numbers

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The preceding set of papers has explored various aspects of the role of language in mathematics education. The papers reflect the work of individual contributors. An important part of our collaboration, however, has been the conversation between us. This paper reflects on aspects of that conversation, as we draw together some of the themes that have emerged during our work. In particular, we discuss some of the implications of our analyses for theory, policy, practice and inter-disciplinarity in mathematics education and applied linguistics.

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In the papers in this collection, we have explored aspects of the role of language in mathematics education. We have moved beyond simplistic notions of mathematics being 'language free', or alternatively and conversely, of mathematics being a language. Drawing on the two data extracts[1], we have considered a number of distinct, but related aspects of mathematics classroom interaction, including the role of ambiguity, the role of definitions and the learning of mathematical vocabulary. In this paper, we use these explorations to consider wider issues concerning the nature of academic mathematical discourse (or what Street, this volume, terms 'academic numeracies') and the relationship between the teaching and learning of mathematics and students' induction into mathematical discourses. What can we say, for example, about the nature of educational policy, particularly in relation to the role of guidance for teachers? What can we say about the role of theory in understanding classroom interaction? What implications do our analyses suggest for mathematics classroom practice? This paper also addresses an additional issue, concerning the nature of inter-disciplinary collaboration. How has our collaboration gone beyond the individual disciplines we customarily inhabit?

On Theory

In our analyses, we have drawn on various theoretical perspectives on language in context: Halliday's Systemic Functional Linguistics, 'New Literacy Studies' and discursive approaches to vocabulary learning and meaning making. These different perspectives share the position, now common in 'social' linguistics, that it is not sufficient to attend to word level, sentence level or even text level accounts of meaning making. A more 'social' approach suggests that much work in making meaning occurs in more 'hidden' processes, partly organ-

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ised or constituted by social action, social structure or ideology. This approach involves a shift in theoretical orientation to language, literacy and mathematics, seeing them as less essentialist, less decontextualised, more fluid, 'fuzzy' and shifting with context. Mathematics, rather than being seen as reified, abstract knowledge, is seen as constructed, or reconstructed, through social practice (Baker *et al*., 2003). Our analyses all highlight the nature and use of some of these social mathematical practices in one mathematics classroom. From this perspective, many 'problems', such as the notion of 'ambiguity', come to be seen instead as a resource, a resource implicitly exploited by the teacher and her students. We are not attempting to generalise empirically from our few examples, but rather to accentuate and synthesise key points underlying our understanding of the principles and theoretical assumptions regarding language and learning and their relationship to mathematics. Underpinning these accounts lie significant recent theoretical developments in language studies that may sometimes remain hidden in the debates over policy (see below) that currently dominate schooling in the UK and other education systems in similar policy environments. Hovering beneath this argument about language, moreover, is a further theoretical domain that is touched upon but perhaps less fully developed, namely that of learning. Leung, for instance, notes theories of language acquisition in his account, as he asks the question 'What does the learning of technical mathematics vocabulary and its associated concept/s entail?' Similarly, Barwell relates his analysis of 'ambiguity practices' in the 'dimensions' extract to the participants' exploring and learning about dimension as a mathematical concept. Indeed recent developments in learning theory that complement the social turn in language theory provide an implicit backdrop to our analyses. Relevant ideas include Rogoff's (1990) account of 'participation', Lave's (1988) account of 'situated learning' or Lave and Wenger's (1991) notion of 'communities of practice', all of which lurk beneath the surface of the accounts given here of the classroom discussion of dimension. The papers represent, then, accounts of current approaches to language and to learning as they relate to mathematics in school and offer a challenge to those that dominate much policy at present, as we discuss below.

On Policy

Official curriculum guidance and advice are in some sense hybrid entities in the UK. On the one hand, they carry the weight of the highest public professional authority and the force of a quasi-statutory instrument, especially when they are designed to support particular policy initiatives and associated national curricula. Once promulgated, traces of these pronouncements can be found in the fabric of professional discourse and practice – in school inspection menus, professional development literature, teaching materials, and above all, in the ways teachers think about and talk about their work. On the other hand, teachers have seen a rapid succession of policy statements, curriculum specifications and guidance on curriculum priorities and teaching approaches in the past 15 years. Each generation of such documents tends to promote initiatives that claim to 'solve' or, at any rate 'reduce' perceived problems linked to existing curriculum and teaching provision. Under such circumstances, we feel that the value of any curriculum guidance and advice should be gauged within a wider policy context and, more importantly, against the backdrop of relevant research.

The guidance and advice on mathematical vocabulary, the subject of this discussion, has appeared at a time when there is a good deal of official privileging of subject content (over process or exploration). The emphasis on learning formal subject vocabulary is not necessarily directly associated with any particular teaching methodology, but it does chime in quite well with the general feel of the policy position that learning in school is primarily about learning subject content. Formal subject vocabulary is presented as part of the desired content. In this collection, we have, by drawing on a number of different disciplinary perspectives and research traditions, demonstrated that:

- formal mathematical vocabulary is not a set of self-evident factually objective terms that transcend debate or even controversy;
- the doing of mathematics in school clearly goes beyond learning formal mathematical vocabulary;
- learning, more specifically participating in learning activities, involves the use of both formal and informal language.

Seen in this light, the particular example of guidance and advice we have discussed should be regarded as a useful reminder or an amplification of one aspect of a much wider mathematics curriculum. Like the many other policy emphases that have come (and disappeared) before it, this particular example can be seen as the latest addition to a long series of educational policy pronouncements that implicitly impose particular perspectives on language, learning and teaching on individual subjects such as mathematics. We feel it is important that such perspectives are exposed, explored and challenged, both in the light of alternative theoretical perspectives as discussed above, and in the light of mathematics classroom practice, which we briefly address in the next section.

On Practice

Moving from considering policy to considering practice, it is useful to be reminded that what teachers and students actually do in their classrooms does not and cannot follow exactly the guidance laid down in policy documents (or research papers), however carefully constructed or policed this may be. The guidance is necessarily recontextualised by teachers drawing on a range of other knowledge, experience and influences. Such recontextualisation of the National Numeracy Strategy has been evident in the discussions of the classroom transcript in the papers in this collection. The teacher's practice is not rigidly constrained by the models of pedagogy, language and language development offered by the official discourse. Rather, she shapes the lesson moment by moment in response to student contributions. While it is widely accepted among teachers of mathematics at all levels that language is important to the teaching and learning of mathematics, there is much less consensus about what this might mean, about its practical implications or even about what mathematical language is.

A central argument offered by the papers in this collection has been that 'fuzziness', ambiguity, multiplicity of meaning and exploratory discussion in everyday language should be recognised, not as failure to achieve a truly mathematical degree of precision, but as essential to making mathematical meanings and to learning mathematical concepts. As Leung identifies, it is through exploratory and informal use of everyday language that the most insightful mathematical thinking appears to emerge. There is, therefore, a tension for teachers between the commonly held notion that mathematics is, or should be, precise, and the suggestion that children may learn mathematics better when it is exploratory and ambiguous. Teachers and learners of mathematics need to exploit both the power of 'correct' mathematical language and the opportunities for learning and creative mathematical activity provided by more informal mixtures of specialist and everyday ways of speaking.

A further key finding emerging from the papers in this collection has been that mathematical language, whether in a primary classroom or an academic research paper, cannot be characterised simply in terms of specialised vocabulary. One aspect of mathematical language going beyond vocabulary is the characteristic form of argumentation from definitions described by Morgan. Research into secondary students' understanding of mathematical proof has shown that, even when they are aware of the conventional forms of such arguments, students may choose to use everyday language instead, resulting in arguments that lack crucial elements of rigour and generality (Healy & Hoyles, 2000). The importance and difficulty of constructing arguments are recognised to some extent in current curricular emphases on developing mathematical reasoning, though, as with the NNS approach to vocabulary, the advice provided to teachers suggests a somewhat simplistic and formulaic approach (see e.g. DfES, 2004). There is a need, then, for teachers to be supported in developing more explicit awareness of the variety of forms that mathematical communication may take, as well as a need for resources to support them in working with learners to develop a fuller understanding of the nature and role of mathematical language.

The analyses we have offered of the classroom transcript have shown that primary aged children and their teachers can engage in original, exploratory mathematical discourse, going beyond the requirements of the curriculum. They have also provided some suggestions of approaches to achieving this. For example, Street's and Barwell's papers show how the teacher in this classroom creates space for the children to intervene with their own ideas and explore ambiguous meanings by relinquishing some of her own authority, making provisional statements herself and opening up a meta-commentary on the representational validity of the materials available. At the same time, Leung suggests that learning new vocabulary is itself an exploratory activity. Indeed, the processes he describes as part of learning vocabulary (exploring limits and boundaries, generalising and extending meaning) are equally applicable to processes of mathematical investigation and discovery. Rather than adopting the NNS advice to make children 'move on and begin to use the correct mathematical terminology as soon as possible', teachers and children are likely to benefit from an approach that allows exploration of both language and mathematical ideas to be mediated by the use of informal everyday language.

On Inter-disciplinarity

Our collaboration has been between researchers working in two different broad academic fields, those of applied linguistics and mathematics education.

Each of these disciplines has its community, its texts, its journals and conferences. Linguists have shown occasional interest in mathematical discourse (e.g. Halliday, 1978). A part of the mathematics education community has long been interested in linguistic issues and has drawn on several approaches developed by applied linguists (see the introduction to this set of papers for a brief overview). There has, however, been little interaction between the two communities. Over the past two years, we have worked on joint presentations and discussions at conferences in both communities, as well as the present collection of papers. What has this inter-disciplinarity added to the development of our ideas?

In general terms, each discipline has raised questions and offered insights and ways of addressing questions raised by the other. Thus, for example, the mathematics educators highlight one student's statement, 'There's no such thing as a one dimensional . . . ' (turn 46) as mathematically significant, prompting applied linguists to consider, in terms of the language practices of the classroom, how such a statement comes about (Street, this volume). Similarly, a linguistic analysis of changes in interaction patterns (Leung, this volume), leads mathematics educators to explore how these changes relate to the nature of the mathematics being discussed (Barwell, this volume). Clearly, our analyses benefit from the perspectives of the two disciplines. An analysis of the role of definitions (Morgan, this volume), for example, gains from both mathematics education insider perspectives and outsider perspectives. This interaction between the two disciplines is more than a case of applied linguistics providing tools of analysis for mathematics education. Equally, it is more than a case of mathematics education providing a little detail to help the linguists make sense of the data. Members of any academic community tend to see and question particular issues, those which are valued and salient within their discipline. By working together, we have broadened the scope of our inquiry and see more than any one perspective makes visible. This is not to say that any one perspective is better, or that we need to synthesise our different approaches into something new. Rather, we argue that the diversity of perspectives we have employed have enriched our findings.

Following this experience, we suggest that similar benefits might be achieved by teachers from different specialisms working together. This does not just mean that language teachers should share their expertise with teachers of mathematics. A simple juxtaposition of the two domains is unlikely to be informative. The value of such dialogue lies in the insights that arise from looking at issues raised as significant from the 'other' perspective through the eyes of your own specialism, and from having the opportunity to learn how others perceive the familiar issues of your own field. This implies that teachers, schools and policy makers need to value such inter-disciplinary dialogue and, crucially, provide time for it to happen and space for it to flourish.

In Conclusion

We have argued that doing and learning mathematics and 'doing' and learning language are social activities. Language is about more than words; mathematics is about more than numbers. We have shown, furthermore, how a view of language as social practice is inseparable from a view of mathematics as social practice. As the participants in the Dimensions extract explore the language of dimension, so they explore the mathematics. Equally, as they explore mathematical concepts, so they must explore and develop a language with which to pursue their exploration. The extract shows in microcosm, the development of a part of the discourse of mathematics within a particular community of practice co-incident with the development of mathematical ways of thinking, knowing and understanding. Aspects of the participants' learning and aspects of their ways of knowing mathematical principles, however, remain 'hidden'. The explicit statements about learning and about language that frame schooled learning in general and 'academic numeracies' in particular, only concern certain limited features of learning and knowing. Our theoretical and analytic accounts are all attempts to make visible aspects of the more implicit processes through which learning and knowing come about. In rendering the implicit more explicit, we believe we can contribute to the learning, not only of pupils, but also of teachers, textbook writers and policy makers. We hope that our analyses, in revealing some of the hidden dimensions of learning and knowing, offer practitioners and policy makers opportunities to develop their practice, through reflecting on what counts as knowing, both in terms of children's learning in school and of their own ways of knowing.

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Note

1. For details of the texts referred to in this paper, which is one of a set, see the introductory paper 'Language in the Mathematics Classroom', this volume, pp. 97–102.

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