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National Association for Language Development in the Curriculum
the national subject association for EAL

The role of language in mathematics

Contributing Author
Richard Barwell

How do you see the role of language in mathematics? How you respond to this question may well influence how you think about English as an additional language in mathematics classrooms. If you think that mathematics *is* a language, you might see learning English as less important: if children can learn to speak mathematics, their proficiency in English might not matter. Whilst the idea that mathematics is a language is a useful metaphor, it should not be allowed to obscure the complex role of language in mathematics (see Pimm, 1987). Children's English *does* matter, as the Framework for Teaching Mathematics (DfES, 1999) acknowledges English provides the means for children to think about mathematics, as well as to express that thinking. If children are not supported to develop mathematical English, they are less likely to be able to participate fully in mathematics lessons, and so will have fewer opportunities to make progress in the subject.

This guidance is aimed particularly at teaching mathematics at Key Stages 2, 3 and 4, although the ideas it contains are also likely to be applicable at Key Stage 1. The guidance will outline some key issues related to the following areas:

- the nature of mathematical discourse;
- bilingual education and mathematics;
- the assessment of mathematics.

Let me begin, however, by inviting you to work on a problem.

A problem of mathematics and language: la chèvre de M. Séguin.

> Il était une fois un fermier qui s'appelait M. Séguin. M. Séguin avait une chèvre, une bien belle chevre. Chaque jour, M. Séguin se levait tôt le matin et amenait la chèvre au pré, pour qu'elle puisse brouter l'herbe. Elle avait faim ce chèvre! Dans le pré M. Séguin avait construit un abri qui protégait la chèvre contre les intempéries. Il attachait la chèvre au coin de l'abri avec une corde. Il la laissait brouter toute la journée. L'abri était sur roues afin que M. Séguin puisse le bouger lorsque la chèvre avait fini de manger l'herbe à sa portée. Votre problème est celui-ci: quelle superficie de pré la chèvre peut-elle manger?

How did you get on? Did you read the problem right through to the end? Perhaps you know a little French and were able to make some sense of it. Did you work out what the problem is asking you to do? Can you work on the problem and report your findings in French? I have used this problem with secondary PGCE mathematics students. I present the problem verbally, much as it is written above. When I later ask the students how they felt when I did this, they often talk of feeling frustrated, angry, incompetent, disempowered and of switching off. They get an insight into what learning mathematics through a language only partially understood might feel like.

What is challenging about the above problem in terms of language? Are there words that you do not know? Perhaps the scenario is unfamiliar. How do you decide what information is relevant for the problem? How do you identify the mathematical task embedded in the text? How could the problem be adapted so that you are able to engage with the task? And what does a learner's response to such a task tell you about how much mathematics they can do? These are the kinds of questions that teachers need to think about as they consider how best to support learners of EAL in their mathematics lessons.

One strategy might be to simplify the problem: remove any unnecessary information, use simple words and add symbols, pictures or diagrams. Whilst this approach might provide a short-term fix so that learners know what mathematics they need to do, in some ways it is problematic. Children do ultimately need to be able to engage with the language of mathematics as they find it in textbooks and exam papers. There is a danger in simplifying texts too much or for too long so that learners of EAL are not exposed to school mathematical discourse. When I use this problem with PGCE students, I repeat the story, without changing the language directly. I draw pictures and use gestures and (rather poor) mimes of goats and grazing. I repeat key words (e.g. superficie = area) and relate them to my pictures. The students quickly understand the mathematical problem; they also begin to see some strategies that might support learners of EAL in mathematics.

The problem I have discussed above raises several issues concerning the teaching and learning of mathematics for learners of EAL:

- What is the nature of mathematical language? The above problem does not use much mathematical terminology, yet it may still be difficult to engage with the mathematical task.
- How can bilingual learners be supported to learn mathematical English while they learn mathematics? What does research in bilingual education imply would be helpful to support students in mathematics? What strategies might support such students?
- How can mathematical attainment be fairly assessed if learners are still developing their proficiency in English? If learners of EAL find word problems hard to make sense of, for example, they may get them wrong, particularly in a test situation. Would such incorrect responses fairly indicate the learner's mathematical or linguistic proficiency?

The nature of mathematical discourse
Mathematical discourse has a number of distinctive features, including some aspects which are particular to mathematics classrooms.

Mathematical discourse has a specialist **mathematical vocabulary**, which includes:

- technical terms specific to mathematics (e.g. equilateral, quotient, probability);
- specialist use of more general terms (e.g. line, factor, frequency);
- mathematical terms that use everyday words used for unrelated ideas (e.g. function, expression, difference, area).

Students learning EAL need to learn relevant mathematical vocabulary (see the NNS booklet *Mathematical Vocabulary* for a list). In the above problem, the word 'superficie' (area) is clearly important. Learners of EAL may also need to appreciate how mathematical terminology relates to everyday usage. Strategies might include vocabulary matching activities; use of word lists and dictionaries; providing plenty of opportunities for students to use words in spoken and written form.

Mathematical discourse includes **specialist syntax**, particularly in relation to the expression of logical relationships. Thus the use of *and*, *of*, or, *a*, *if* and *then* to define mathematical relationships are all significant. Such words, are, however, easy to overlook. Strategies to support the development of syntax could include the use of writing frames or partly structured sentences (e.g. matching a set of 'if' clauses with a set of 'then' clauses).

Mathematical discourse involves the use of **mathematical symbols**. Such symbols range from numerals to more specialised notation. These symbols have a syntax of their own, so $2x$ and 2^x mean different things. Again, matching tasks could support the connection of symbols with the related words.

Mathematical discourse includes specialised **ways of talking**, including written and spoken forms of mathematical explanation, proof or definition, as well as text types like word problems. These broader ways of using language are important in expressing mathematical ideas and reasoning. Strategies for supporting to the development of mathematical ways of talking have to involve creating rich opportunities for students to explain their thinking. Thus, structured pair or group work is likely to be supportive.

Finally, in classrooms, mathematical discourse also includes **a social dimension**: the particular ways that students and teachers talk in mathematics classes that are not specifically mathematical, but that are associated with mathematics. Instructions, for example, might include expressions like 'simplify' or 'complete the following'. Teachers often use 'we' to refer to 'people who do mathematics' (e.g. we use x to represent an unknown). And word problems, like the example above, are to be interpreted in a way that is specific to mathematics lessons.

A range of useful examples of activities that support language development in relation to different aspects of mathematical discourse within mathematics teaching can be found in both *Access and Engagement in Mathematics* (DfES, 2002), and in *Secondary Mathematics and English as an Additional Language* (Driver, 2005)

Bilingual education and mathematics

In the section on bilingualism and second language acquisition Charlotte Franson highlights 5 key research findings concerning the education of bilingual learners in mainstream classrooms. These points can be related more specifically to mathematics:

Point 1: The learner's first or home language plays a significant role in the learning of the second language in terms of cognitive, linguistic and socio-cultural influences.

This point provides an argument for trying to find ways to incorporate the use of students' home languages into mathematics lessons. Strategies might include students working with same-language partners for some of the time; inviting parents to participate in mathematics lessons from time to time; working with bilingual colleagues; using bilingual dictionaries and other resources. The National Numeracy Framework encourages some of these ideas, such, as for example, the investigation of number systems in different languages

Point 2: Bilingual education can be very beneficial in the development of the second language.

This point follows on from the previous one and suggests that by supporting students to develop the mathematical aspects of their home language is likely to have a positive effect on their mathematical English. For example, in *Access and Engagement in Mathematics* (DfES, 2002), Vasant Mahandru describes how he uses dual languageTurkish-English loop cards as part of his oral and mental starter strategies to support learners' engagement with and use of mathematical definitions.

Point 3: Most EAL and bilingual learners will develop a functional level of English in the first two years of schooling in English but they will need continued support to develop the cognitive academic language proficiency necessary for academic success. This point implies that mathematics teachers should not assume that a student who appears to communicate effectively in 'everyday' English will have the necessary proficiency to communicate at the same level in mathematics. The demands of mathematical English are higher than those of everyday English and students may need to be support to develop the necessary proficiency. In the word problem given above, for example, even if you have some understanding of French, you might have found the mathematical language unfamiliar. You might be able to work on the problem, but not have enough proficiency in mathematical French to report your findings. An outline of the nature of mathematical language is given above. Strategies might include the use of writing frames, matching cards, dictionaries and word lists as well as explicit discussion of mathematical language. Driver (2005) suggests a wide range of strategies, including, for example, a matching activity, in which learners match algebraic expressions with equivalent linguistic expressions (e.g. n2 might be matched with 'n-squared' or 'n multiplied by n').

Point 4: Learning a second language will not necessarily proceed in an orderly and systematic fashion. Learners will use prior linguistic, learned and world knowledge, learners will learn when there is a need to communicate and to learn, and learners will learn when they are motivated to learn.

This point is equally likely to apply in mathematics. It suggests that it is worth creating mathematical situations which motivate students' need to communicate their ideas. Strategies might include instruction-giving activities; group presentations of extended work; mathematical newsletters featuring students' work; competitions.

This point also suggests finding ways to relate school mathematics to learners' out-of-school contexts. Those of you who know a little about farming may have made more sense of the French word problem than those who do not. The NNS Framework suggests strategies such as asking students to bring and explain mathematical games from home. More involved work could include asking learners to investigate the use of mathematics in the home or community and prepare a report about their findings. The report could be written in more than one language and could be supported by the use of writing frames (see Driver, 2005, *Section 6* for an example).

Point 5: Learning a language and becoming bilingual is also about learning and living in different societies and cultures. It is not just about acquiring a new language, but also about understanding another culture, and developing another identity.

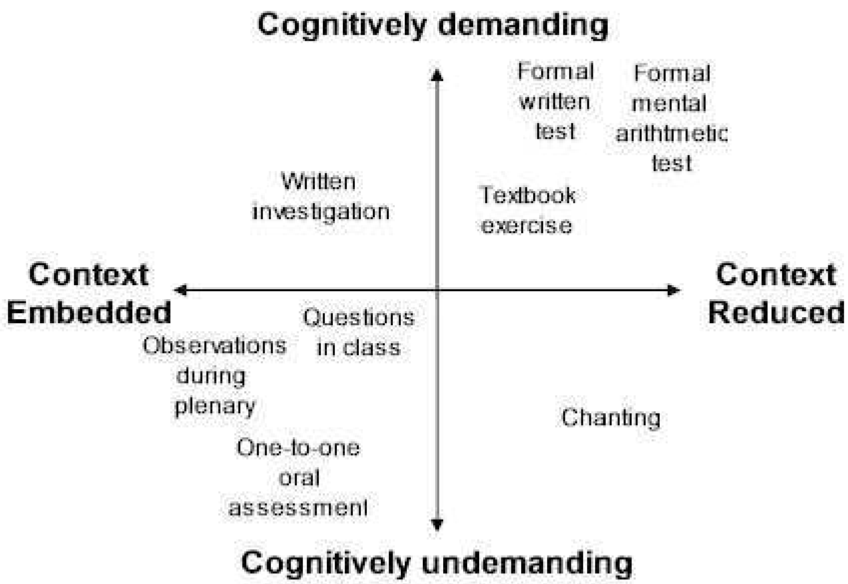
This point implies that bilingual students are learning how to be a learner of mathematic as much as learning how to do and talk about mathematics. Their experiences of schooling and of learning mathematics may be very different from what they find in the UK; they may have little prior mathematics education. Students from East Asia may be used to a formal, memory-based approach to mathematics, for example. Learners from many communities may see mathematics as 'right or wrong' and mathematics teachers as always right! These experiences may provide an uncomfortable contrast with approaches used in UK mathematics classrooms, in which, for example, the NNS encourages attention to a variety of methods and explanations, often generated by the learners. The National Curriculum inclusion statement expects teachers to respond to the diverse needs such students may have. Such an expectation is often challenging, and the inclusion statement offers three guiding principles (with examples) which can be seen as a starting point for developing practice:

- Setting suitable learning challenges;
- Responding to pupils' diverse learning needs;

- Overcoming potential barriers to learning and assessment for individuals and groups of pupils

The assessment of mathematics and EAL
Assessment in mathematics covers a range of approaches, from nationally set standardised tests, to teachers' judgements of attainment based on systematic classroom observation. Assessment of the mathematical attainment of learners of EAL is, however, highly problematic, since any method of assessment relies to some extent on learners' use of English. In principle, for example, mathematics tests and examinations should not be proxy tests of English. In practice, this principle is difficult to implement. If you were unable to tackle the problem at the top of this page, it is unlikely to have been because you were not able to do the mathematics.

One challenge for teachers of learners of EAL is to evaluate the possible demands and appropriateness of different forms of assessment for particular learners. If such demands can be evaluated in some way, teachers will be in a better position to make decisions about which methods to use and to develop strategies to support learners of EAL. A framework proposed by Cummins (e.g. 2000, p. 68) provides a useful conceptual tool with which to tackle this challenge. Cummins relates two key dimensions: (language-related) cognitive demand and (communicative) context. In the version, below, various forms of mathematical assessment activity are placed within the quadrants.



It can be hypothesised that activities in the upper right-hand corner of the diagram are likely to be more problematic for learners of EAL, and so less reliable indicators of their mathematical capabilities. Similarly, those in the lower left-hand corner are likely to be more useful to teachers. Given a choice, teachers could therefore seek to develop or use assessment methods closer to the lower left-hand corner.

Unfortunately, formal mathematics tests are widely used in the UK. Given this situation, teachers could look for ways to, in effect, move methods of assessment away from the upper right-hand corner towards the centre of the diagram. For example, mental arithmetic tests provide little linguistic context but are highly demanding, since they rely entirely on listening – there is no opportunity to interact with the questioner. Learners could be prepared for such tests by developing activities in which listening skills are practiced. Learners could be provided with a set of questions, for example, and are then asked to identify which question is being orally asked.

In national tests, some modest special arrangements are permitted for learners of EAL. Provision sometimes includes extra time, translation of mental tests and the translation of some words and all instructions.

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