Use and meaning: what students are doing with specialised vocabulary

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Words are powerful and give students the ability to communicate mathematical ideas and relationships precisely. Yet not all students are able to access the technical vocabulary encountered in mathematics lessons. Students use mathematical words in various ways and teachers give students different opportunities to both use mathematical language and to develop meanings associated with this language. In this paper we explore how previously low attaining students use mathematical vocabulary during their lessons and how their teachers offered different opportunities for language use. The analysis reveals that there are shifts between developing language use and developing language meaning that depend upon the meaning demonstrated by students in their interactions.

Keywords: Vocabulary, word meaning, classroom interaction.

Introduction

Being able to communicate about mathematics is a key part of the process of learning mathematics, yet many students face difficulties and barriers when learning to use the language of mathematics. Learning mathematics is far more than coming to know specialised vocabulary (Morgan, 2005) but this vocabulary can support and enable students to develop their understanding of mathematics. In this paper, we examine students' use of mathematics specific vocabulary using an ethnomethodological approach, and explore the opportunities offered by the teacher to use this vocabulary in different ways within classroom interactions. In particular, we offer examples of how these opportunities differ depending on the meaning the students appear to have for these specialist terms as they use them during whole class interactions. These opportunities include the different prompts that the teacher used to generate a need for the specialist word to be used in the interaction.

Learning mathematical words

What it means to know a word is multifaceted and complex, and different researchers have attempted to categorise this complexity in different ways. We take a situated perspective on learning mathematical words, focusing on their use within what Moschkovich (2012) calls the *mathematical Discourse practices* of the classroom. One simple way of categorising word knowledge is to make a distinction between receptive or passive knowledge and productive or active knowledge, which distinguishes between students recognising and understanding words that they hear or read and students using words for themselves either in speech or writing (Bravo, Cervetti, Hiebert, & Pearson, 2008). Sfard (2008) makes a further distinction between three types of active use, routine-driven, phase-driven and object-driven use. However, students use words in different ways and within these distinctions there is more of a continuum of what it means to know a word.

Within mathematics there is a specific need to use words very precisely in contexts that are often unique to mathematics (Bauersfeld, 1995). Students' understanding of definitions, informal or formal, also needs to enable them to make distinctions between what is or is not an example or specific use.

Furthermore, the contexts in which students need to use words are often highly abstract and connections with existing knowledge or often only possible within mathematical contexts too.

Many researchers have emphasised the role of contexts and connections to other words and ideas in the learning of new words. Words need to be studied in their natural habitat; within sentences with a communicative purpose or within contexts where the need for the word arises (Moschkovich, 2015). Students need to be able to make connections with what they already know (Bravo, Cervetti, Hiebert, & Pearson, 2008). In the case of words that students are meeting for the first time in the mathematics classroom, these connections may need to be with existing mathematical words or concepts with which the students are more familiar.

Students also need to experience the word in a variety of contexts in which it may arise (Bolger, Balass, Landen, & Perfetti, 2008). Yet in mathematics, students may only experience a particular word in one lesson or across a short sequence of lessons. Some words rarely arise within new topics and some words may only be met when a topic is revisited months or perhaps years later. In mathematics, we also tend to use language more precisely than we do in everyday contexts, and use particular technical terms in a narrow range of contexts. This can make it easier to misuse words or lead to broader concept definitions than those generally accepted by mathematicians.

Methods

The data analysed for this paper comes from a larger project where two groups of mathematics teachers worked with the authors to develop their students' use of mathematical language. This involved the teachers regularly videoing themselves teaching and sharing clips of this teaching in meetings for discussion. The project itself did not focus on lower attaining students, but for the analysis discussed below we consider videos from classes identified as having low prior attainment as the teachers sharing the clip focused their discussion on their students' use (or lack of use) of technical vocabulary. These classes were described by the teachers as including many students with identified additional literacy needs, such as a learning disability or very low reading age. In the UK classes are usually set by prior attainment, particularly in secondary school (age 11-18), and the class were the lowest attaining classes within each school. The extracts included in this paper come from one such class and are used to illustrate the complex relationships between developing word meaning and developing word use. The students are around 12 years old. The video clip that the extracts are from were chosen by the teacher herself to share with her department in order to explore with them and the authors how her students were using mathematical language and the difficulties they faced when doing this.

Within the videos that the teachers shared with us, all the whole class interactions were transcribed and for the analysis below, all student turns that included a mathematics specialist word or phrase were identified. These turns were then analysed within the wider sequence of interaction looking specifically at what the students were doing with these word or phrases and how this use was reflexively related to the teacher and student turns that occurred before and after. An ethnomethodological approach was used for the analysis which is an inductive process focusing on how the participants themselves interpret what is going on through how they interact in the classroom.

Specifically, the analysis presented in this paper uses Conversation Analysis to focus on the actions of the teacher and her students when using technical mathematical vocabulary to describe properties of numbers. The analysis particularly focuses on vocabulary use as this arose explicitly in all the classes considered and was a focus for the teachers sharing the videos in the team meetings.

Results

In this section, we explore the relationships between students developing meaning for particular mathematics specialist vocabulary and students using this specialist vocabulary. Students use mathematical specialist vocabulary in different ways during classroom interaction and we illustrate how teachers offer different opportunities for students to use these words and/or develop their meaning in relation to these words. The opportunities offered for students to use specialist vocabulary themselves is influenced by the previous meanings students display in the interaction.

The extracts used below to illustrate the different opportunities come from Emma's lesson on properties of numbers. The particular lesson was towards the end of a sequence of lessons looking at factors, multiples, and prime, square, cube and triangle numbers. The video focused on a task where the students needed to ask the teacher if she 'liked' different numbers between 1 and 25 (see I like… http://nrich.maths.org/6962 for the task used). Emma used a rule related to number properties to classify numbers as ones that she liked, e.g. those that were a multiple of 3, and those that she did not like, e.g. those that were not a multiple of 3. The students needed to work out the criteria that Emma was using to make the decision of whether she liked a number or not. The first extract below focuses on an example where the numbers were all multiples of three and the second and third extracts focus on an example where the numbers were factors of twenty.

After around 9 minutes of working on the task as a whole-class, the students have identified several numbers that Emma likes and a few that she does not like and have begun talking about whether the numbers belong to particular times tables. The students have offered suggestions that the numbers belong to the three, six, twelve and twenty-four times table (though they have not said specifically that they **all** belong to the three times table or six times table). In turn 145 Emma introduces the word multiple for the first time in this activity and models its use in turn 147. The students continue to use the phrase times table, such as in turn 151 until several turns later where in turn 193 a student offers the rule that they are all multiples of three. From this point onwards within this task different students use both times table and multiple fluently and interchangeably.

The students use the word multiple in both semantically and lexically appropriate ways. Emma repeats both answers and rewards the students for 'a good maths reason'. The need to use the word multiple arises from Emma's prompts to use the word specifically, and her general prompt to use mathematical reasons and mathematical talk. The need does not arise naturally in this context as the students are able to articulate the meanings they are attempting to express using the more informal language of 'belonging to the times table of'.

145	Teacher:	you are giving me (.) such good reasons. as well as thinking about times tables, can you think of the word multiples
146	Student:	yeah.

147 Teacher: so, could we say it's a mult- those- they are multiples of three, they are multiples of six (.) some of them are multiples of twelve, number twenty-four. you are so close to getting the answer.
148 Student: it's that kind of right, because like basically they goes in order, like six, like because they're going down [by]
149 Student: [hey] we just said that (.) hhh

Transcript Omitted

190 Teacher: what was my reason for liking those numbers?
191 Student: because (.) I don't know, they're special.
192 Student: because, because they're all -
193 Student: they're multiples of three

Extract 1 – multiples of 3

Extract 2 comes from the second scenario where the numbers Emma likes are all factors of twenty. Before the extract begins the students have discovered that Emma likes the numbers 5 and 10 but not the number 12. The next student asks if Emma likes the number 20 and then offers a rule that 'ten times two is twenty' in turn 242. The rule focuses on the relationships of twenty being a multiple of 2 and/or 10. This response is repeated before the student also offers that it's 'in the five and ten multiples'. Whilst in what the students are saying they are focusing on twenty being a multiple of 2, 5 and 10, the connection they are making also refers to the relationship that 2, 5 and 10 are all factors of twenty. Additionally, at the end of turn 250 the student is using the mathematical word in a lexically incorrect way but semantically the word is used appropriately. The way that the word is used would be lexically correct if the word multiple was swapped for times tables. This is rephrased by another student into its usual form in turn 256 and it is this response that is repeated by the teacher. Each of these reasons, and other reasons such as the numbers are all even, are accepted by Emma as being 'good maths talk' (turn 259) even though none of them describe all of the numbers that are on the board (factors of twenty). The students are continuing to use the mathematical language in semantically and lexically appropriate ways in that the students are able to use the word multiple to express the meanings they want to convey, and the teacher is rewarding and reinforcing this through how she responds to their suggestions for rules.

237 Student because it's (in the five times table).
238 Teacher or what else could you say?
239 Student it is a multiple -
240 Student it's a multiple -
241 Teacher it's a multiple of five. it's in the five times table, I think I can give you a stick for a good maths reason.
242 Student1 twenty, becau- because ten times two equals twenty.
243 Student oh, no
244 Student oh, yeah.
245 Teacher I do, I do like twenty and your reason was? what was your reason for choosing twenty if [I'm going]
246 Student [oh um]

247	Teacher	to give you a stick?
248	Student1	ten times two is twenty.
249	Teacher	because ten times two is twenty.
250	Student2	and it's in the five and the ten multiples yeah so
251	Teacher	now,
252	Student	so
253	Teacher	you're right that twenty is ten times two. but I like sname's reason. he said it was
254	Student2	it's a multiple of five and ten.
255	Teacher	it's a multiple of five and a multiple of ten.
256	Student3	and it’s even
257	Student	yeah. and-
258	Teacher	and it’s even. okay, um, there's definitely some good maths talk in there.
259	Student	yeah!
260	Teacher	a lollypop stick. you haven't discovered my reason for my choice yet

Extract 2

In Extract 3 the focus of the discussion then shifts closer to ideas around factors following the inclusion of the number 4. In turn 298 Emma indicates that the rule is not that all the numbers are multiples of 5 now that 4 has been included, but the students are still focusing on a multiple relationship as is shown in turn 329 where a student suggests that all the numbers are a multiple of 2 except 5. The interaction continues with the students now referring to a relationship between two specific numbers on the board, such as two goes into four, rather than a general property that is true of all the numbers. After several students use the phrase ‘goes into’ to describe these relationships, Emma prompts for the mathematical word in turn 344. This relationship of ‘goes into’ is generalised to a common relationship by a student in turn 374 but the use of goes into continues. Emma asks again for the maths word that describes this relationship in turn 375. The responses that follow over several turns are all one or two-word answers and include add, divide, multiple, integer, cube number and triangle number. The interaction becomes a game of guess the word the teacher is thinking of, and the students do not give the word factor until turn 461. The relationship being described by the students is bidirectional in that 2 goes into 4 means both that 4 is a multiple of 2 and that 2 is a factor of 4. The distinction between these two meanings is not clear from the students’ contributions and their responses to Emma’s request to name the relationship indicate that factor is not yet a word that they have active control over (and presumably integer too).

297	Student	number four? that's not in the five times table.
298	Teacher	doesn't have to be, does it, or even a multiple of five.
Transcript omitted		
329	Student	so basically, every number except five is a multiple of two.
330	Student	yeah, and ((inaudible)).
331	Teacher	that's true, but I have to have one reason for all my numbers.
Transcript omitted		

342	Teacher	That was really good thinking, you are nearly there, but I didn't hear many maths words. ‘cause, you were thinking, you said two goes into four.
343	Student	yeah.
344	Teacher	what's the posh maths word for goes into?
345	Student	oh, multiple. uh -
346	Student	add.
Transcript omitted		
366	Teacher	you can ask me about another number in a minute, see if that changes anything. sname?
367	Student	um, two times five is ten.
368	Teacher	two times five is ten.
369	Student	and then two, two times ten is twenty.
370	Teacher	two times ten is twenty.
371	Student	so, like they ((inaudible)) and then four times five is, um, 25. so like -
372	Teacher	think that one through again. four times five is…?
373	Student	twenty.
374	Student	so they like all go into each other.
375	Teacher	oh they’re all going into. what is the maths word for the going into thing?
376	Student	divide.
377	Teacher	yes, but there's another maths word that was on your sheet this morning. I'm going to give you the stick.
378	Student	uh, can we get another one if we get the word?
379	Teacher	[laughs] um -
380	Student	uh, I think.
381	Student	integer
382	Teacher	you are talking about [maths aren’t you good good]
383	Student	[integer, integer!]
384	Teacher	that wasn't the maths word, not the one that we're thinking of here. it's all about [things goi]ng into.
385	Student	[subtract]
386	Student	multiple.
387	Teacher	[laughs] and it is to do with dividing, but it's not the word that I'm looking for.
388	Student	[((inaudible))]
389	Student	cubed num[ber]
390	Teacher	[what]'s the connection between all these?
391	Student	cube number.
392	Teacher	there's one missing. shall I put the one missing?
393	Student	triangle number.
394	Teacher	there's one more number here that I like.

395 Student squared.

Extract 3

Emma’s prompts and questions have shifted from asking students to describe the relationship where students’ responses include them trying to express the meaning of the relationship, to asking them identify the ‘maths word’ for goes into. Her prompts attempt to give the students the language to describe the general relationship that their specific examples are beginning to point to. The students are able to clearly explain a relationship of multiples using both formal and informal language, but this is not the case for factors. Here the students are not able to communicate the relationship that all the numbers are factors of 20 either formally or informally. This prompts a shift in the nature of the interaction to the students attempting to name or label the relationship. However, this is unsuccessful and the students are instead blurting out all the other technical words they have encountered this lesson that appear on the worksheet on their desks.

Conclusion

In this paper, we have examined students’ use of mathematics specific vocabulary and the opportunities offered by the teacher to use this vocabulary in different ways. Students need opportunities to construct meaningful discourse about mathematics in order to develop their use and understanding of the language of mathematics (Schleppegrell, 2007). These opportunities were adapted throughout the lesson depending on the meanings the students appear to have for these specialist terms as they use them during whole class interactions. When students demonstrated that they had some appropriate meanings and other ways of expressing mathematical ideas using informal language the opportunities meant students were able to use the technical vocabulary in meaningful ways. That is, they were using these technical words to communicate mathematical ideas and relationships. When the meanings of the words were less clear or where the concept that the words label were less fully formed, these opportunities focused on using words to label or name.

These opportunities were also created through the different prompts that the teacher used to generate a need for the specialist word to be used in the interaction. The need for the word multiple does not arise from the mathematics that the students are working on as they already have words they can use to describe the relationship and they are able to express this relationship clearly. Instead, the need arises from the task and the way the teacher enacts the task. The teacher specifically prompts students to use the word multiple in their descriptions and offers them opportunities to describe the relationship between the numbers on the board. The need for the word factor arises from a need to generalise a relationship and to name this generalisation. Here the teacher uses prompts that offer students the opportunity to name the relationship rather than to communicate the relationship they are attempting to describe.

The use of the technical language involved in communicating mathematics can be a particular challenge for students whose difficulties in learning mathematics are confounded by broader literacy or language issues. In the case of factors the students were able to identify the individual relationship of one number being a factor of another, possibly as this is the same as the relationship of one number being a multiple of another. However, generalising this to a relationship between all the numbers on the board took considerable prompting from the teacher and this was accompanied by the challenge of identifying the word used to describe this relationship. Further research is needed to investigate this relationship between word use and word meaning the interdependence of these two aspects of technical language.

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Transcription Conventions (Jefferson, 1984).

[text]	Brackets	Indicates the start and end points of overlapping speech.
(.)	Pause	A noticeable pause.
.	Period	Indicates falling pitch or intonation.
?	Question Mark	Indicates rising pitch or intonation.
,	Comma	Indicates a temporary rise or fall in intonation.
(text)	Parentheses	Speech which is unclear or in doubt in the transcript.

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