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Language matters in demonstrations of understanding in Early Years mathematics assessment.

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Introduction

While mathematical understanding is not the same as understanding language, the capacity to teach and learn mathematics requires language. Indeed the way language is used in mathematics classrooms has long been recognised as a key factor in successful learning (e.g. Ellerton & Clements 1991; Voigt 1998; Jorgensen 2011). Furthermore, teachers and students interact using language and other resources, such as gesture, pausing and tone of voice to construct meaningful sequences of classroom talk. As Bartolini Bussi (1998:66) notes, "…what has to be learned is determined by the joint activity between the teacher and pupils and that joint activity comprises both the content features of the specific task and the quality of the interaction."

One context where it is important to examine closely the language use of both teachers and students is when students are required to demonstrate their understanding, or lack of understanding, of a particular mathematical concept such as equivalence, classification or sequence (Davis 1991; Cooper & Dunne 2000; Koole 2010). Demonstrations can take place in testing and assessment or during teaching activities. Indeed in early years of schooling, when students' overall literacy is being developed alongside numeracy, oral language is the primary means by which students' progress through a maths curriculum can be assessed. Demonstrations by children are often elicited by teachers as instructions or questions, and so success in demonstrating understanding is crucially connected with what both teachers and students say and do.

For students, a demonstration of understanding or non-understanding rests not only on what they actually know about the targeted concept, but also on a) how well they have understood what is being asked of them, and b) how well their response is fitted to demonstrate (non-) understanding of the concept. For teachers, success comes from a) how well their instructions are tailored to elicit appropriate demonstrations, and b) their capacity to interpret students' responses as demonstrations of (non-)understanding in terms of what was being asked of them. In this sense, students' success or otherwise in communicating what they understand about a mathematical concept depends not only on their capacity to use and understand the language associated with that concept, but also the degree to which they understand the language of the instruction itself. For example, in order to successfully demonstrate that they have understood the concept of 2D shape classification, students not only need to know what words like 'shape', 'sides', 'triangle', 'square', and 'same' mean when applied to shape classification, but also what teachers mean when they ask 'Can you put all the same shapes together?', or 'Are these the only shapes [on the table]?'. Cowan (1991:56) cautions that

> "… care must be taken when using terms such as *same*, *different* and *more* and interpreting children's use of them. Their meaning varies with context and can pose problems, even in interactions between adults. In interacting with children we cannot assume they will understand what we mean or ask us to explain"

Teachers must therefore also develop a sensitivity to the ways students may use verbal and non-verbal resources to carry out demonstrations of understanding. This is particularly important with young children, because they are still learning classroom language, and with children who speak a different language variety at home from the maths classroom because one cannot assume that students' linguistic resources, such as their fluency in Standard Australian English will be adequate for the purposes of demonstrating understanding. Our data show this because they come from a Year 1 class in an Indigenous Australian community school, thus involving young children who do not come from a Standard Australian English speaking background.

This paper presents a Conversation Analytic examination of interactions between teacher and student in a one-on-one oral mathematics assessment to show how local uses of both language and non-verbal behaviours affect the progress of the task, including whether the child has demonstrated understanding, what it is they have demonstrated, whether the teacher immediately moves on to a new task, or whether further work is undertaken to prompt students to further action. In some cases there is no problem in demonstrating understanding, of either the mathematical concept or the language of the teacher. In other cases there is evidence of problems in achieving a successful demonstration. Some of our examples show that what the children are finding difficulty with is understanding the teacher and/or the mathematical language, rather than understanding the mathematical concepts themselves, because the students ultimately do demonstrate an understanding of the concept either in that particular phase of the test, or as part of another phase of the test. However, we also found cases where children never get to demonstrate successful understanding. This raises the question as to whether this is because problems associated with understanding and using language have obfuscated the task requirements, or whether the student genuinely has not grasped the mathematical concept.

Our findings show how seemingly very small factors, such as the choice of a particular word, the repetition or reformulation of a phrase, the occurrence of silence, the rise or fall of an intonation contour can have significant impacts on the unfolding of an assessment sequence, and this in turn can affect what the assessments are able to reveal about what children are actually demonstrating with their answers. The significance of many of these factors only become apparent under the degree of scrutiny we have applied here using Conversation Analysis and this is probably beyond what teachers can notice from moment to moment as these events unfold. However, the fact that they do affect what happens in an interaction is evidence of the sensitivity and competence of both teachers and children in their reactions to very small things as they work their way through a collaborative process.

Language use in Indigenous Australian maths classrooms

It is well recognised that Australian Indigenous children who live in predominantly Indigenous communities are unlikely to speak Standard Australian English, which is the language of education and indeed the language of most teachers in Australia. The kind of language spoken in the home environment ranges from traditional Indigenous languages to newer contact languages (e.g. Kriol) to Indigenous English varieties.

Most Australian studies on language and maths education in Indigenous contexts focus on communities where children speak traditional languages as their first language, and where they are raised in a cultural environment where use of mathematical concepts have been shown to be at variance with the priorities of a 'Western European' education system (e.g. Watson 1988; Graham 1988; Kearins 1991; Jorgensen 2011).. It has been claimed that linguistic and cultural differences contribute to a lag in the development of mathematical proficiencies for language minority children, especially when they also lack proficiency in the standard language of the classroom (e.g. Jones 1982; Cocking & Chipman 1988; Thomas 1997; Flores 1997).

Our study represents a different kind of Indigenous context because the school in which we have collected our data is situated in a community where traditional languages are no longer spoken. The first language of the community is a contact variety based on English which differs substantially from Standard Australian English (e.g. Flint 1968; Gardner & Mushin 2012), what we call a 'community vernacular'. This community vernacular has its roots in the NSW pidgin language that developed originally for communication between English speaking colonisers and Aboriginal people (Dutton 1983). As traditional language use declined due to the decimation of populations, removal of people from their own country, and separation of children from adults who could pass on their traditional languages, this Pidgin expanded to become a language used between Aboriginal people, and eventually as a language passed on as a first language to children. Today the community vernacular has a grammar that is systematically different from English, sharing grammatical features in common with other English-based contact languages, such as the varieties of Kriol spoken in parts of the Northern Territory and Kimberley, albeit with more convergence with the lexicon and grammar of English. The result is a variety of language that appears mutually intelligible to Standard Australian English speakers, but which should not be considered to be simply a non-standard dialect of English on both historical and linguistic grounds.

Children come to school with little prior exposure to Standard Australian English, but due to a lack of understanding of these speech varieties, they are mostly enrolled as English speakers. Their language differences are often poorly understood, or are treated as deficiencies (Flint 1968; Teasedale & Whitelaw 1981; Malcolm 1982; Jorgensen 2011; McIntosh et al 2012).[1]

This is quite a different situation from that faced in schools where children are more easily recognised as speakers of languages other than English. When children come to school speaking a language that is often seemingly intelligible to non-Indigenous teachers, it can be harder to identify where language-related problems might lie. Nonetheless teachers in this and other communities with similar language situations regularly report difficulties in understanding the students (see e.g. Carter 2011). The following observation from a teacher is indicative of the length of time it takes for teachers to learn enough about the language differences to allow for effective communication:

> "I don't think you ever do really have a handle on it [the 'community vernacular']. I think it's something that you learn bits of all the time. But in terms of what I do in the classroom, it probably took me a good part of my first year to get used to and it's probably only this year in my second year that I've been able to actually start drawing on some of that stuff" (Teacher at Cunnamulla State School, 2010)[2]

Research has been emerging on the impact of this kind of language background in Queensland on Indigenous student performance, particularly in terms of learning Standard Australian English as a second dialect or language (McIntosh et al 2012), which does of course impact on all key learning areas. There has been as yet no research carried out in terms of the impact in maths classrooms specifically

Our data do show clear examples where language differences between the teacher and students affect the progress of assessment tasks. However we must show caution in ascribing such language related problems to the Indigeneity of the students. Even children who are recognised as speaking a variety of language at home that is at least close to the standard language of the classroom are still required to learn the language associated with classroom mathematics (e.g. Pimm 1987; Rowland 1995). These uses may differ considerably in the ways that such language is used at

[1] There is increasing departmental recognition that such children do not come from a Standard Australian English backgrounds and must learn it as a second language or dialect. This is seen, for example in the QLD Department of Eduacation, Training and Employment 2011 report *Embedding Aboriginal and Torres Strait Islander Perspectives in schools: A guide for school learning communities*, and the 2011 *Aboriginal and Torres Strait Islander Languages statement*.

[2] This quote is from interviews by the third author with teachers throughout Southwest Queensland during 2010 as part of her work with the Queensland Department of Education, Training and Employment Indigenous Schooling Support Unit.

home. For example, Walkerdine (1988:25ff) demonstrates how relational concepts like *more/less*, *same/different* that are taught as contrastive pairs from early schooling are not used in this way in home language among preschoolers, especially those from lower socio-economic backgrounds, where only 'more' is used, and then usually in relation to food.

The performance of the students we have recorded may be directly related to their particular language background, or it may reflect other factors. Our study has so far focused on classroom interactions and so we have no evidence of the ways that mathematical thinking and mathematical language is used in the home environment and how this may affect learning in the classroom. However we can show ways in which inadequate linguistic resources may be at the heart of students' capacity to adequately demonstrate that they have understood a mathematical concept.

Data

Our data come from a larger corpus of video-recorded classes in a primary school situated in an Australian Indigenous community in Central Queensland. We have been recording the first three years of schooling. The school has 100% Indigenous enrolment. Children at this school typically perform below the numeracy standards of other schools, including others with high Indigenous enrolment, as shown in the school's 2011 NAPLAN (National Assessment Program – Literacy and Numeracy) results (http://www.myschool.edu.au/SchoolSearch.aspx). There is therefore a concerned interest by the school and the relevant Government departments to identify the causes of lower achievement as well as practical ways of improving maths outcomes.

The data was collected as part of a larger project 'Clearing the path towards literacy and numeracy: Language for learning in Indigenous schooling', funded by the Australian Research Council and the Queensland Department of Education, Training and Employment, which is developing an evidence-based understanding of some of the language and interactional bases for success or failure of knowledge transfer for learning in early years classrooms.

In this paper we focus on a collection of one-on-one Year 1 oral maths assessments as part of the Queensland Year 2 Diagnostic Net. This testing was conducted every term through Prep and Year

1 until 2011, after which Queensland adopted the Australian National Curriculum for Mathematics. The test runs for about 15 minutes for each child and students are required to demonstrate a wide range of mathematical understandings relating largely to number, but also including contrastive relationships 'more/less' and 'same/different' applied to objects and numbers, one-to-one distribution using 'each', pattern recognition, and the use of money (Queensland Studies Authority 1997). This kind of testing format thus provides a rich environment for the investigation of how demonstrations of different kinds of mathematical understandings are organised.

The tests were administered during class time by the teacher. The rest of the class were engaged in small group activities under the supervision of the Teacher Aide. The teacher however was still engaged in classroom management and at times had to shift her focus from the test to managing other children, or commenting on their work.

We recorded these assessments as part of our method of recording naturally occurring classroom activities. That is, we did not originally plan to record these tests specifically. For this reason only a subset of students were recorded undertaking the test. The teacher sat at approximately 60 degrees to the student. Two video cameras were used at approximately 135 degrees to each other so that one camera faced both the teacher and the child from the front, and the other camera was positioned to capture what the student was doing from almost behind the child. In addition to the audio recording from the video cameras, each child wore a digital voice recorder with a lapel-mike. This enabled us to hear even very soft utterances by each student.

Instructions were given entirely orally by the teacher. Students sometimes were required to give an answer orally, but in other cases could demonstrate understanding simply by their actions, for example to draw the completion of a pattern, or to colour in squares that had matching numbers of objects in them. In addition to use of language in directly addressing teacher instructions, students also used language at times to check either that they had understood the task correctly, or that they had provided the correct response. In the latter cases, the teacher usually responded with as little content information as possible (e.g. 'Give it a try').

Our data show that children at times appear not to understand the instruction itself, leading to a lack of performance in the particular task, in turn leading to the assessment that they have not acquired a particular concept. Yet not understanding an instruction is not the same thing as not understanding the concept itself. As Davis (1991:42) notes:

> "…the questions and answer situation does not provide us with privileged access to children's understanding…Stated simply, children do not necessarily interpret adult language in the way that we intended."

The interactive nature of this kind of assessment means that while the actual problems and questions are fixed, there is wide scope for variability in the ways that each phase of the test is approached, including the use of language in formulating the assessment questions or instructions by the teacher, and the ways that teachers and children respond to each other in each phase. For example, if an instruction results in a lack of response from the child, it may be repeated, or reformulated, and this in turn may affect what the child does next.

What emerges is that in some cases it is very clear whether a child has understood the concepts or not, and this is demonstrable not only in the response to the test question, but also in the way that the child goes about answering the question. In other cases it is less clear what the child knows. This does not necessarily mean that the child does not understand the concept, but rather that their answer may have been influenced by a range of local contextual factors.

Methodology

Our purpose is to document and track these factors as they emerge and to show how the student and the teacher orient to what is transpiring in the interaction. To do this we have used Conversation Analysis. This approach and tool set sees conversation and all other forms of talk, including talk in the classroom, as what Schegloff (1992) has called the primordial site of human sociality. As part of this sociality, talk is the medium through which participants reveal to each other their understandings of what is happening in the conversation, an achievement that relies not only on language and its prosodic overlays, but also on embodied actions and non-linguistic vocalisations. So parties in talk build upon each other's talk in sequences of utterances, each of which not only has meaning, but is also an action (for example, a question, an instruction, an answer). Each of these actions is normatively built to fit the prior action, so that all utterances can be seen to be, as Heritage (1984) put it, both context-shaped and context-renewing, in the sense that what people attend to changes with each utterance; thus context can be viewed as ever-changing and dynamic. In order to study talk as interaction, Conversation Analysts use recordings of naturally occurring events. For recordings with young children, whose language is still developing, and who routinely respond non-verbally, video recording can be seen as essential if one is to understand well what is going on.

A further crucial aspect of the Conversation Analysis approach is an avoidance of speculation about participants motives, thoughts, beliefs or values, all of which are hidden from inspection, except as they are manifested through behaviours in social interaction, that is, observable conduct. This leads to an insistence that it is the participants' own understandings of what is going on in the talk that needs – as far as it possibly can – to be traced, tracked and understood. Amongst the ways to gain this perspective is through the next turn proof procedure. That is, a great deal of how an utterance has been understood by an addressed participant in a conversation is through an examination of how they respond to that utterance, and how in turn their own utterance is responded to. To be able to observe this, an analyst needs to transcribe in order to capture at least some of the richness of interactional conduct. This includes words of course, but also how the words are spoken, as well as silences, simultaneous talk, prosodic and intonational features, amongst others. Transcription is not merely capturing what was said for later analysis, but also a means to become very familiar with the data, and further, to provide some evidence for a reader of the transcript or extract to back up any claims that are made. More recently, Conversation Analysts have made considerable inroads into establishing evidence for how participants reveal their understandings of each other's utterances, and how they construct their utterances on what they take the others to know (Heritage 2012a, 2012b). The Conversation Analytic approach lends itself well to the questions we ask in this paper.

Analysis

What follows are a number of analysed extracts to show a range of trajectories around demonstrations of understanding. We focus on the phase of the test concerning the classification of a set of 2D paper cutouts. The cutouts consist of equal numbers of squares and isosceles triangles.[3] There were two precise sizes (big and small) and three primary colours (red, yellow and blue). There was one cutout for each possible classification according to shape, size and colour – twelve altogether. Students were asked to classify the objects according to a selected property of the cutouts (eg. 'Can you put the shapes in the same colour?'), or more generally over the whole set (eg. 'What is the same about all of these?').

We begin with an extract that exemplifies a demonstration of understanding without evidence of misunderstanding.[4]

(1) 110908-Yr1-Part2.2 (3'56"-4'17")

```
1  T:  Can yuh put them in: or-, the s:ame colour.
2      (1.1)
       ((A begins to sort by colour))
3  T:  >You c'n put, all the same colour, together.
4      (14.4)
       ((A completes sorting task. Sits back and looks at T))
5  T:  Oka:y.
```

This extract shows a task that is completed unproblematically, with the student, Amelia[5], demonstrating that she has understood both the teacher's instructions, and an understanding of the classification of the two dimensional objects according to colour. Amelia proceeds to sort the shapes into piles without delay and without any further communication with the teacher. The teacher's reformulation in line 4 is not required, as Amelia had by this point already begun sorting the shapes. This takes her about 14 seconds, after which she sits back in her chair to show that she has finished. This is one of the few examples in the classification phase of the test that is completed so smoothly.

Our next three extracts illustrate a less smooth trajectory, with some work needed between teacher and student before a successful demonstration of understanding is ultimately achieved.

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[3] Because these shapes were hand cut with scissors, the angles on the triangles may not have been exact, but the triangles all appear to be isosceles to the naked eye. In many cases the children manipulated the triangles by hand but this did not appear to interfere with their ultimate classification of all of the three sided cutouts as the 'same' as we show here.

[4] Our transcriptions use a simplified version of Converation Analytic transcription conventions. Words are mostly transcribed orthographically, except where there is a marked pronunciation. Some student utterances that use community vernacular language are accompanied by an English translation in italics directly underneath. Other transcription conventions are given in the Appendix.

[5] The student's names have been changed.

(2) 110908-Yr1-Part2.2 (2’55”-3’55”)

1 T: So now, show me. (0.5) we've got a:ll these shapes up here.
2 (0.5)
((T pushes pile of shapes towards A))
3 T: Can you put the, <S:AME sh:apes> together.
4 (2.8)
((A picks up one shape from the top of the unsorted pile and looks at T))
5 T: Yep. (0.2) so so:rt them.
6 (0.6)
7 T: Can you put a:ll the same shapes, together.
((A picks up two big squares and puts them aside))
8 (5.8)
((A picks up two small squares and puts them together))
9 A: Miss, ON’Y (.) two li’l squares, aren’ a:y.
Miss, only two little squares, aren’t they.
10 (0.5)
((A puts the two small squares next to the big ones))
11 T: Well have a look.
12 (27.9)
((A puts all the big squares together, then all the small squares, then all the big triangles, then all the small triangles, then looks at T))
13 T: Oka:y. now, is that putting the sh:apes together?
14 (0.2)
15 A: No,
((Shakes head))
16 (0.5)
17 T: So how can we put the shapes together.
((A puts the small triangles on the big triangles.))
18 A: Thish.
This
19 (1.6)
((A puts the small squares on the big squares))
20 A: Deh.
There
21 (0.4)
((A sits back, puts hands behind head))
22 T: Oka:y.

At the beginning of a new test task in extract (2), the teacher pushes the mixed up pile of paper cutouts in front of Amelia (line 1). The teacher then instructs her to ‘put the same shapes together’ (line 3), with marked stress on ‘same shapes’. She picks up the top shape and looks at the teacher (line 4), showing that she is having some difficulty in beginning the task. The teacher’s response is ‘Yep’, showing that she has treated Amelia’s eye contact as seeking confirmation, adding ‘So sort them’ in line 5, then reiterating the instruction, ‘Can you put all the same shapes together’. The problem Amelia has had at this point is not about the mathematical task, but about understanding the teacher’s instructions, which is further demonstrated by her proceeding to pick out big square shapes, and then over the next 36 seconds or so (lines 8 to 12), she sorts the cutouts into four piles:

big squares, small squares, big triangles and small triangles. So Amelia has responded by not only sorting according to shape, but also to size. This could be seen as non-fulfilment of the task, though she has demonstrated that she *can* sort according to shape. The teacher pursues this by asking in line 16 'Now is that putting the shapes together?'. Amelia responds to this as an information question (her 'No' in line 19 accompanied by a shake of her head), by which she claims to know that she has not completed the task. The teacher then asks, 'So how can we put the shapes together' (line 17), to which Amelia's immediate response is to demonstrate that she does understand that putting the same shapes together means classifying the cutouts according to how many sides and angles they have because she places the big squares on the little squares and the big triangles on the little triangles.

Examples like (2) show us that even when the student is ultimately able to demonstrate understanding of a concept, considerable interactive work may be required to reach this point. While we cannot know what led Amelia to sort according to size as well as shape, we can see that it was not a lack of understanding of the concept *shape*, as a geometrically defined object, and thus must have been her understanding of the instructions. If this had been a written test, or an oral test in which the teacher did not follow up her initial instructions, it is likely that Amelia would not have been able to complete the task successfully, and thus demonstrate her capacity to distinguish shape from size as properties of objects.

One final point about this extract: the word 'same' which was introduced as an emphasized target word at the beginning of this phase in line 3 (it is loud and has a lengthened initial consonant and with the word 'shape' is uttered slower than the rest of the utterance), suggesting that this was at least part of what was to be demonstrated was an understanding of the concept 'same'. Amelia's classification of the cutouts into according to both shape and size may reflect the ambiguity with what the term 'same' should apply to, and the extent to which sameness could be attributed to properties of the cutouts. While the teacher has indicated that 'same' should apply to'shapes' in line 3, Amelia appears to have treated this as a minimal requirement because she has sorted according to shape, but additionally sorted according to size. When the instruction is reformulated in lines 17 and 21, the word 'same' is no longer used by the teacher ('Is that putting the shapes together?') thus removing that ambiguity. Amelia's response is to reduce her piles to two geometric shapes – triangles and squares.

Our next extract shows how problems with a word, here the general attribute word 'size', can affect a student's capacity to demonstrate understanding of classification according to size.

(3) 110908-Yr1-Part2.1 (0'04"-0'54")

```
1  T:  'Kay? can you sort, and put all the same s:i:ze
2      together.
3      (8.2)
       ((D begins sorting shapes, puts two big squares
       together. T watching D))
4      (8.0)
       ((T attends to another child who has approached the
       table, D continues to sort shapes, but according to
       shape, not size))
5      (7.3)
       ((T returns gaze to D, who completes her sorting
       according to shape, not size. D finishes sorting and
       looks at T))
6  T:  So: Davida, >can you pud all< the b:ig
7      ones, together? an' all the little ones, together?
8      (17.4)
       ((D starts re-sorting as T says 'little', moving the
       shapes into two piles, one big, one little))
```

Davida is asked in this task to put objects of the same size together. In a similar way to Amelia in extract (2), Davida eventually shows that she understands how to classify according to size, but the difference is that she begins the task incorrectly by sorting according to shape. This suggests she has not understood the instructions, and has not picked up that 'size' is the target classification criterion. She begins by putting two big squares together, with the teacher watching, so at this stage, there is no indication that she has not understood the instruction. Another child then approaches the table, and the teacher turns to attend to him. As she is talking to him, Davida continues to sort, and it becomes apparent now that she is sorting according to shape. After eight seconds (line 4), the teacher returns her gaze to Davida, and watches for 7.3 seconds (line 5) as she continues to sort the objects incorrectly. Only when Davida has finished does the teacher follow up with a newly worded instruction, to put the 'all the big ones together and all the little ones together' (lines 6 to 7). This significant rewording replaces the scale attribute 'size' with the antonymic values on this scale, 'big' and 'little', which are much less abstract attributes than the superordinate term 'size'. With this simplification, Davida has no problem in completing the task successfully. This demonstrates again that, even though we cannot know what it was, there was something about the wording of the instruction that obscured Davida's understanding of the concept behind the word 'size'.

In our third example of a student not understanding instructions, but eventually demonstrating a grasp of the concepts being tested, Gary is the testee. He is asked to sort the objects according to colour. In this example, however, the student requires more scaffolding from the teacher to complete the task successfully than in the previous examples.

(4) 110908-Yr1-Part2.3 (3'13"-4'50")

```
1  T:  Now Gary. (0.7) can you put (0.3) ALL of these
2      sha:pes, (1.2) together, (1.3) in the same COlour.
3      (1.2)
       ((T sits back. G picks up one shape and looks at it))
4  T:  Can you put a::ll the same colour shapes together.
5      (42.7)
       ((G picks up a number of shapes, then selects the yellow
       ones one by one, finally placing them on the desk in
       front of T one at a time. Red and blue shapes remain
       unsorted))
6  T:  Whad about these ones, Gary?
       ((T points to remaining shapes))
7      (35.8)
       ((G picks up red shapes, puts them next to the yellow
       shapes, and then does the same with the blue shapes))
```

Gary is first asked to 'Put all of these shapes together in the same colour' (lines 1-2), which is followed by a reformulating 'Can you put all the same colour shapes together' (line 4). This is the same task that Amelia completed without a hitch in extract (1). She had been asked, in a slightly different wording, 'Can you put them in the same colour. You can put all the same colour together'. (This was Amelia's second sorting task using these shapes, whereas for Gary, sorting was a new task in this test, which explains 'them' in her question, and 'shapes' in his.) Gary picks up all of the yellow shapes and places them in front of the teacher, leaving the red and blue shapes unsorted. This takes him over 42 seconds (line 5). So why does he not put *all* of the shapes together in the same colour, as Amelia had done? He has demonstrably understood that shapes of the *same* colour should be put together, but he has not put *all* of them together.

The words used in both forms of the instruction to Gary are almost identical. However, the syntax has changed: In the first version, the teacher puts the phrase, 'in the same colour' at the end of the sentence, a long way syntactically from the 'all of these shapes', while in the second she uses a dense noun phrase, ‘all the same colour shapes’, so that ‘all’ is next to ‘same colour’. It seems likely that the more immediate juxtaposition of ‘all the same colour’ has led to Gary linking ‘all’ with shapes of the ‘same colour’ rather than with all the shapes. Under this interpretation, his understanding of the task is not about shapes, but about colour. In line 6, when he has completed his sorting of the yellow shapes, the teacher points to the remaining unsorted shapes and asks, ‘What about these ones, Gary.’ With this prompt, Gary demonstrates that he is in fact capable of sorting all three colours into their respective groups.

In the next two extracts students do not demonstrate understanding of the concept being tested, but there is evidence that at the heart of the problem is the understanding of the language, rather than the mathematical concept. In extract (5) Gary is asked to put all the big ones (i.e. shapes) together. He does not demonstrate an understanding of classifying the shapes according to size. The question is whether he has not understood this concept, or the instructions.

(5) 110908-Yr1-Part2.3 (6’15”-6’53”)

```
1  T:  Okay, can you put all the big ones together.
2      (4.6)
       ((G stands up, pushes the three big triangles together,
       each of a different colour))
3  G:  N:o?
4      (18.1)
       ((G completes putting big triangles together to make
       a 2D array, and then sits down))
5  T:  Is that the only big shapes?
6      (0.8)
7  G:  Hm?
8      (0.3)
9  T:  Are they the only big shapes?
10     (1.5)
       ((G moves the big triangles around on the table,
       moving some other shapes aside))
11 G:  Nn::, yeah.
```

To understand what is going on in this extract, it is necessary to describe what happened in the task immediately prior, in which he had been asked to ‘[p]ut all the triangles together, and all the squares together’. He completed this task successfully, with some prompting from the teacher, thus demonstrating an understanding of the concept that shapes may be differentiated by numbers of sides and angles.

In extract (5), Gary is instructed to 'Put all the big ones together' (line 1). Gary proceeds to put the three big triangles together, ignoring the squares. A problem here is the word 'ones', which Gary takes to be referring to the shapes he had just been sorting, namely the triangles. He thereby demonstrates that he can distinguish 'big' objects from others, but he does not exhaust the supply of big shapes available on the table. At line 6 the teacher asks 'Is that only the big shapes?', which Gary does not understand (line 7), and she quickly repairs the grammar to 'Are they the only big shapes'. After shuffling the shapes for a few moments, Gary answers affirmatively. They then move on to the next task in the test. So while Gary has demonstrated that he can classify according to size, he has not demonstrated that he understands the *word* 'shape', though there is evidence that he has an understanding at least of the *concept* 'shape' as a geometric object that can be classified according to numbers of sides and angles (here triangles and squares). Note that in extract (4), where he was asked to sort according to colour, the word 'shape' was also used. However, there is no evidence in that extract that he understood this word, as it was the juxtaposition of 'all' and 'the same colour' in the second version of the question that prompted him to complete the task successfully. In this example, although he was asked in line 9 specifically whether he had exhausted the supply of big *shapes*, and not big *triangles*, he stays with the triangles, which he has exhausted. So we have evidence here that Gary understands the concept 'shape', but is not able to link his understanding of the shape words 'triangle' and 'square' to the superordinate term 'shape'.

In the next extract, the teacher asks a question that is open to a range of interpretations.

(6) 110908-Yr1-Part2.2 (5'33"-5'59")

```
1  T:  An' wha's something tha's th' S:AME about
2      [all of these things;
       [((T waves pencil over the shapes))
3      (0.3)
4  A:  Das dis:,(.) dis dis;=
       ((A points first to the two piles of triangles, as she
       says 'das dis', then pauses briefly, then points to the two
       piles of squares, 'dis dis'))
5  T:  =N'yeah,= wha's the s:ame about them;
6      (0.7)
7  A:  Triangles,
8      (3.0)
9  T:  An' wha's ^different;
10     (1.5)
11 A:  °Dis;°
       ((A points to pile of big squares))
12     (2.0)
13 T:  N'whad is it; 'melia?
14     (0.4)
```

```
15 A:  S:quares;
```

The design of the teacher's question in line 1, 'What's something that's the same about all of these things', with the unspecific words *something* and *thing*, provides an opening for Amelia to identify a category that is shared by everything in front of her, that is, classifying something that the whole set has in common. What this property might be is left unspecified and it remains unclear from the teacher's formulation what particular aspect of classification is being assessed. Is she assessing the capacity to identify a superordinate category of property such as 'shape' or 'size' or 'colour'.(eg. they are all shapes)? Or is she asking the student to select a property and identify within that property a congruent parameter?

Amelia already has four piles in front of her, sorted according to size and shape. Amelia's response in line 4 is to point both physically (with a gesture) and verbally (with a deictic 'dis') to all four piles. The timing of the pointing, with a slight pause in the middle, demonstrates that she has separated the first two piles (triangles) from the second two piles (squares). What Amelia has done is to provide an answer that has scope over the set ('all of these things') and to find commonalities ('something that's the same'), thereby answering the question. The teacher, though, is not satisfied with this answer, as testified by her follow-up question in line 5, 'N'yeah, what's the same about them,' which suggests that she accepts that Amelia has demonstrated in her answer that she understands the requirement to include 'all' the cutouts, but not what is the 'same' about them. Amelia's answer, 'triangles', correctly identifies *shape* as a relevant property of the cutouts by which they can be classified but has scope only over half of the set and this is therefore an unsatisfactory response. However her verbal answer also does not match her original gestural and deictic response in line 4. While Amelia has shown that she understands the concept 'shape', she is not using this word as a superordinate term. Unlike Gary, though, in extract 5, Amelia has clearly understood the meanings of the words 'all' and 'same' in this context. With the teacher re-asking the question, Amelia was given the message that her first answer was inadequate, and this leads her to providing a different answer that appears even more inadequate.

Next, in line 10 Amelia is asked 'What is different'. Her response is to point to the other half of the set, namely the squares. This indeed identifies something that is different, which is one possible interpretation of what the question required, but it does not demonstrate difference over the whole set, or difference as a comparative concept. Whether Amelia understands this concept or not is obscured here by the fact that the teacher's question in line 9 no longer makes explicit that the whole set is targeted.

In the final extract we can see how Davida responded to the same question about sameness over the whole set in a similar way to Amelia, but using full sentences rather than the general demonstrative pronoun 'this'.

(7) 110908-Yr1-Part 2.1 (0'55"-1'37")

```
1  T:  M'ka:y;(0.7) So,= no:w,= Miss Davida.= >c'n you tell me
2      something,<= that is the S:AME about all 'f these shapes;
3      (1.0)
4  D:  [U m : : : : ,]
5  T:  [>abou' all ev] these things in front of you.
6      (2.0)
7  T:  >Wh[a's some]thing that's the s:ame.
8  D:     [D e h - ]
9      (1.1)
10 D:  Deh're triangles,= an' deh're squares?
11     (8.3)
       ((T writing))
```

While the question to Davida is elaborated and repeated with different formulations to those presented to Amelia in (6), her responses show strong similarities to Amelia's. Whereas Amelia used 'this' and pointing, Davida says, 'They're triangles and they're squares'. Like Amelia, she hasn't said that they are shapes. However, she has been able to use language to identify features of sameness within the set, which is what Amelia was doing with her pointing. In Amelia's case, the teacher treated the response as inadequate, while in Davida's case, the response was treated as complete. In other words, the more linguistically sophisticated answer brought the sequence to a close.

Conclusions

The extracts we have presented here show different ways that language (non-) understanding may interfere with a student's capacity to demonstrate understanding of a mathematical concept such as classification, geometry, and equivalence. These include a lack of understanding of a particular word associated with the mathematical concept being targeted (e.g. the word 'shape' in extract 5, or the word 'size' in extract 3 as properties by which objects may be classified), and/or a lack of understanding of language associated with the scope of the task (e.g. the scope of ‘all’ in extracts 4 and 6). We have shown that in some cases, such language understanding problems may be resolved with further interactional work. For example, the reformulation of the teacher’s instruction in extract 3 from ‘same size’ to ‘all the big ones and all the little ones’ resulted in a successful demonstration of understanding. The success of many reformulations indicates that the precise wording of questions and instructions by teachers has an important impact on students capacity to demonstrate understanding, especially if the understanding revolves around what so-called basic vocabulary means (eg. a word like ‘same’ or ‘more’ - Walkerdine 1988). In other cases however, the language problems never appeared to be resolved, leading to an appearance of a lack of mathematical understanding.

The demonstrations of understanding we have examined here come in the context of an assessment exercise, where the best kinds of responses are ones where a student provides a correct response to a question without further prompting . Nevertheless we see a number of examples where the teacher did reformulate instructions, or ask prompting questions (e.g. ‘Is that putting the shapes together?’) designed to extend the task and to give students further opportunities to demonstrate understanding. This option is not available to students taking a written test, or an oral test administered in groups where an individual student’s initial response may not be under such close observation. We have seen that in some cases, the teacher’s extension of the sequence resulted in a successful demonstration of understanding of the mathematical concept, although this is not always the case.

It should be noted that while we did not provide actual examples in this paper, there were cases where the teacher did not always give students further opportunity to demonstrate understanding, even when their answer was clearly wrong or inadequate. This suggests some sensitivity on the teacher’s part to as to where an extension may be warranted. This may, for example, account for the reformulation sequence in extract 3 from the more abstract word ‘size’ to the exemplar words ‘big’ and ‘little’ so that Davida was ultimately able to demonstrate her capacity to sort according to size. Note that in extract 5, which covers the same test phase, the teacher does not even start with the instruction to Gary to put the ‘same size’ together, but begins with ‘big’. While she does give

Gary further opportunity to demonstrate understanding of classification according to size, she does not alter her wording of the mathematical language.

Most of our examples illustrate how the students' language comprehension may pose problems for demonstrating mathematical understanding. Our last two examples show that students' capacity for language production may also play a role. That is, while both Amelia and Davida appear to answer the question about sameness over the whole set with the same strategy indicating both types of shapes, the student who provided the more linguistically sophisticated answer was deemed to have responded appropriately, while the student who resorted to pointing gestures was not. In that particular case, the further extension of the sequence resulting from the inadequacy of the gestured response resulted in answers that could not be interpreted as demonstrations of understanding classification over the whole set, but nor could they be interpreted as demonstrations of (non-) understanding.

The Conversation Analytic approach we have taken here allows for close scrutiny of the moment-by-moment unfolding of a maths assessment task that goes beyond what can be expected of any teacher engaged in the assessment of a student's mathematical ability. We see that in some cases the teacher was highly responsive to a student's response, allowing for further work towards a demonstration of understanding. However the identification of particular moments, particular cues (linguistic and non-verbal) that account for how students and teachers manage each phase of the test are only made possible through micro-analysis of well-recorded and well-transcribed natural data.

The classification phase of the maths assessment task we have examined here afforded few cases where students were required to produce language in order to demonstrate undersatanding. We know that these students speak a community vernacular that is systematically different from the Standard Australian English of the classroom, but we are not yet able to say precisely how this language difference affected their performance on this test. For example we don't know if Gary's non-understanding of the word 'shape' in (5) came from the fact that he was not already a speaker of Standard Australian English, or whether he had just not yet learned that particular word as a mathematical term. There are as yet no detailed linguistic studies of Queensland Indigenous community vernacular languages, although there is recognition that such work is necessary in order to better understand the processes of language acquisition and accomodation that must take place when these children begin schooling in Standard Australian English (eg. Macintosh et al 2012). Our research program includes a description of the variety spoken by these children, but this work is still in its infancy. We do not yet know, for example, the ways in which words like 'same' and 'all' might be used in home language use, and the extent to which objects in their home world are classified according to shape, size and colour as they were asked to do in this assessment.

The Australian Indigenous children we have been examining face many well-documented educational challenges, many of which are associated with general socio-economic indicators of poor educational outcomes, such as poverty, remoteness, and health (including chronic hearing problems). While all children must learn the culture of the classroom as part of early years schooling, the children in this community must also accommodate to a new language variety that we claim requires a larger investment in cognitive effort than Standard Australian English-speaking children must deploy when they too must learn the new language of mathematics education. Our data does not specifically point to which aspects of interaction are specifically related to the student's cultural and linguistic background. It does however point to the care that must be taken by teachers and test designers in maths assessment to ensure that there is clarity between conceptual knowledge of mathematics and the language that cloaks it. A test which is able to tease these two aspects of maths education apart could lead to better means of explicitly teaching the language of maths to children who speak Indigenous community vernaculars, while more accurately acknowledging their existing mathematical competencies.

Appendix: Transcription Conventions

(0.0)	silences measured in tenths of a second
((Words))	descriptions of actions of speakers are placed between double parentheses
=	latching: adjacent turns with no gap and no overlap between them
?	"question" intonation (i.e. rising pitch)
.	"period" intonation (i.e. falling pitch)
,	"comma" intonation (i.e. level pitch)
<u>u</u>nderline	syllables delivered with stress or emphasis by the speaker
CAP	stretches of speech delivered more loudly than the surrounding talk
°word°	stretches of speech delivered more softly than the surrounding talk
wo:rd	the lengthening of a sound is marked through colons: each colon

	represents approximately the length of a beat
>words<	talk that is faster than its surrounding talk
<words>	talk that is slower than its surrounding talk

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