The Hidden Dimensions of Mathematical Language and Literacy

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I draw attention to the distinction between reductionist views of 'language' and the rich and complex ways in which we might approach language as social practice and suggest the latter view is evident in the set of papers collected here. Socially oriented linguists, including those in New Literacy Studies (NLS), look beyond reductionism, to consider more complex 'social' features of language and literacy. This perspective includes: viewing language and literacy as a process rather than as a fixed entity and as a resource rather than as a set of rules; exploring the role of language and literacy in implementing social agendas and in establishing relations between participans, such as their role in establishing and challenging power relations; and the relation of language and literacy to other means of communication and meaning making, such as visual, gestural, iconic that are usually woven in with language use. I consider how appropriate it might be to apply aspects of these approaches and in particular of the 'academic literacies' approach linked to them, to what we might term the 'academic numeracies' at play in the texts under consideration. These perspectives entail an assumption that participants deploy 'hidden knowledge' of the features of language, literacy and numeracy in order to accomplish their social ends and that the task of the researcher is to bring into view and to unpack these hidden dimensions. Identifying such 'hidden' features of classroom discourse can, then, help teachers and policy makers recognise important communicative features of classroom interaction that are missed when the focus is on 'correctness', ' definition', formal features of language and 'lack of ambiguity', as in some curriculum documents and approaches.

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'Academic Numeracies'

My colleagues' papers have distinguished between the rather reductionist view of 'language' implicit in the *National Numeracy Strategy* and the rich and complex ways in which we might approach language as social practice. Socially oriented linguists, including those in New Literacy Studies (NLS), also look beyond reductionism, to consider more complex 'social' features of language and literacy (cf. Street, 1995). This perspective includes: viewing language and literacy as a process rather than as a fixed entity and as a resource rather than as a set of rules; exploring the role of language and literacy in implementing social agendas and in establishing relations between participants, such as their role in establishing and challenging power relations (Gee, 1999); and the relation of language and literacy to other means of communication and meaning making, such as visual, gestural, iconic that are usually woven in with language use (Kress & van Leuwen, 2001).

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I would also like to consider how appropriate it might be to apply aspects of the 'academic literacies' approach (Street, 1999) to what we might term the 'academic numeracies' at play in these texts (as opposed, for instance, to the numeracies required in everyday life (see Baker *et al.*, 2000; Street *et al.*, forthcoming). These perspectives entail an assumption that participants deploy 'hidden knowledge' of the features of language, literacy and numeracy in order to accomplish their social ends and that the task of the researcher is to bring into view and to unpack these hidden dimensions. What, then, are the 'hidden dimensions' that such a view of language and literacy might help us 'see' in the NNS statement and in the 'dimensions' discussion? I will suggest some indicative ways in which the material might be re-viewed from these perspectives.

Application of These Ideas to the 'Dimensions' Transcript

I would like to start with two questions regarding K's utterance in turn 46 of the 'dimensions' transcript (see introduction[1], this volume, Appendix 2): 'There's no such thing as a one dimensional shape coz a line is kind of like a rectangle filled in'.

(1) What is the significance of such an utterance?
(2) How is a student facilitated to make such a statement?

If the significance of the utterance (question 1), is low, then question 2 does not matter much. If the significance of the utterance is high, then it is worth exploring question 2 further.

(1) Why would the utterance be significant? An NLS approach would suggest that the utterance is evidence of a pupil being facilitated to explore rather than regurgitate mathematical principles, to take authority rather than reproduce the teacher's authority. These are significant, if not for tests at this age, then for later development in mathematics. The academic discourse here is that of a partner in exploration rather than a passive recipient. What we know of research on academic literacies suggests such exploration, authority and partnership are important features of accessing the discourse of the academy – features that are often 'hidden' behind more formal demands on students' knowledge of surface features of language (see Lea & Street, 1998). There is, then, enough here to warrant further investigation.
(2) How is a student facilitated to make such statements as: 'There's no such thing as a one dimensional shape coz a line is kind of like a rectangle filled in'? (turn 46).

There are earlier indications of how the teacher is facilitating student response. Following initial turns 1–7 in a more traditional teacher/pupil IRE pattern, at turn 7 the teacher sows seeds of doubt about the basic question of dimensionality, followed by an open-ended question that facilitates a lively exchange (turns 7–9):
[italics in [ ] indicate my comments]

7 **T:** Are there anything else to say. F.
[the teacher cues F to add something not yet articulated]
8 **F:** Um a (three dimensional shape) has breadth, length and height.

9 **T:** Well done. This would be a two dimensional shape *(draws a square)* (. . .) and a three dimensional shape will have an extra dimension. That would be a solid shape *(draws a cube)* okay G.

The teacher gives positive feedback – 'well done' and then makes a provisional statement 'this would be . . . ' that allows students to later adopt the same interpretive modality (see Hyland 1999, 2002, on ways in which 'scientific' authors indicate the provisionality of their claims through use of hedges and mitigation). The teacher also uses the presence of a researcher (RB) to develop the idea of discussion, thereby relinquishing authority and facilitating student intervention, e.g. turns 12–14:

12 **T to RB:** (do you know what) a one dimensional shape (is)?
13 **RB:** A one dimensional shape
14 **V:** I know what a one dimensional [shape is
15 **RB:** [go on
[the researcher allows and encourages the student intervention and the student speaks with authority – 'I know..']
16 **V:** A line

The researcher RB continues in this vein by asking a hypothetical question that gets a number of students trying out answers which he validates (turns 17–20):

17 **RB:** (. . .) so what's a no- a zero dimensional shape
18 **?** Nothing
19 **?** A dot
20 **RB:** Yeah. It's got no length, no width, no height

The student, K, who later utters the key statement for present purposes had not at this point intervened and the conversation proceeds along the same lines for a number of turns (turns 24–43) with the teacher picking up the 'dimensional' question that eventually cues K in. She frames this discourse by offering a metacomment on the situation of the class and of herself as all affected by the materials they have to work with – i.e. she too is subject to outside pressures, she cannot just play God (see Street & Street, 1991, for a similar point about a teacher's attitude to learning of language in an Elementary classroom). She points out (line 41) that the sets of materials that are provided to help explain the principles being addressed in this lesson actually raise a problem: the plastic shapes are intended to show circles, rectangles, etc. and to be 'two dimensional'. But, as she points out in turn 41 in response to a student query in line 40, they are actually 'three dimensional' since the plastic itself gives them some thickness:

40 **J:** (m a two dimensional is flatter . . .)
41 **T:** Yep flat. Look. (*picks up a plastic circle from a set*) I don't like these (. . .) coz they look like three dimensional don't they. They're thick but they're not meant to be, they're meant to be two dimensional. Okay, they're flat shapes (*picks up a square*).

A student suggests it is actually a cylinder and she agrees:

43 **T:** Yeah that's a cylinder (*laughs, waves circle*) (and that's a)

and a student responds:

44 **?** a cuboid

Again the teacher responds positively here to a student interpretation that another teacher might simply have corrected as formally 'incorrect':

45 **T:** cuboid

She then waves the square and explains why the appearance of a cylinder and a cuboid was misleading:

45 **T:** But it's not meant to be it's meant to be flat. *[at this point K is indicating interest and she cues him in]* Yes K.
46 **K**: There's no such thing as a one dimensional shape coz a line is kind of like a rectangle filled in

[the teacher immediately gives positive feedback to validate the point 'Yeah' and then picks up a further extension of the principle] 'What just a line? *(points to board)' [facilitating a genuine interchange with K leading to yet another statement of the mathematical principle in turn 50]*

47 **T:** What just a line? *(points to board)*
48 **K:** Yeah *[uses the teacher's feedback term]*
49 **T:** Like a – what like (. . .) *(gestures thinness)*
50 **K:** a rectangle filled in
51 **T:** *(Giggles)* Very clever. Like a dot *(draws dot)* oops *(erases, does again)* like that.

The teacher offers further non-verbal support for K's insight by giggling and gives explicit evaluative feedback – 'very clever'- followed by an extension of the point – 'Like a dot' – that treats K as a serious interlocutor. She accomplishes all of this without uttering a single complete sentence and then uses multi-modal means to reinforce her point (draws dot) and again mitigates her authority by suggesting she has it wrong 'oops (erases, does again) like that' (turn 51). She then offers a coda, drawing back again from the involvement in process to comment on its significance at a more abstract level:

51 **T:** It's interesting isn't it

Again a student indicates an interest in entering the conversation and which the teacher allows 'Yes H?' using the pattern set up earlier. H follows through the principle now established, that any object that is purported to be two dimensional will always have a third dimension:

52 **H:** (. . .) sometimes things made out of paper's um two dimensional

and again the teacher offers positive feedback: 'Yeah' allowing H to continue with the point, whilst again the pupil uses emphasis and gesture to make it:

54 **H:** (. . .) has just a tiny tiny tiny *(gestures thinness)*

The teacher eventually draws this section of the lesson to a close, re-asserting authority and her right to switch topic:

54 **T:** Anyway . . . (changes to next part of lesson).

We might hypothesise that the presence of the researcher provided a stimulus that enabled the teacher to switch from traditional IRE authority to more dialogic mode. We would need evidence from other classes to establish how frequent this mode of interaction is for her, though we might infer from the students' confidence and facility in coming in on open-ended cues that this is not the first time they have encountered it.

Implications for Pedagogy

What, then, can mathemetics education learn from the application of Applied Linguistics in this way? By treating language as a process and as relational, adopting what Barwell (this volume) terms the 'discursive model' of language and meaning, the analysis from Applied Linguistics can help identify 'hidden' features of the maths classroom that, from an educational perspective, we might see as important scaffolds to learning. These include ways in which the teacher:

- makes the usual formal 'schooled' interactional norms, such as IRE forms of feedback and cuing, more informal and dialogic, reinforcing students' queries and sharing their perplexity;
- uses the vernacular to bring down and share the inquiry, e.g. 'yeah', 'coz' without losing the ability to be precise in engaging with mathematical principles;
- offers a less categorical modality than that evident in the NNS document and in much teacher discourse, such as through use of mitigation, hedges, etc. – 'would be', 'might';
- varies the communicative repertoire with use of multi-modality – gestures, waves objects, draws, points;
- recognises that chunks of discourse smaller than the sentence – such as backchannelling (cf. line 51) – and larger than the sentence – such as framing (line 41) – are significant components of communication.

Identifying these and other 'hidden' features of classroom discourse can help teachers and policy makers recognise important communicative features of classroom interaction that are missed when the focus is on 'correctness', 'definition', formal features of language and 'lack of ambiguity', as in the National Numeracy Strategy statements about language. All of the papers here have noted the problems with the NNS distinction between formal and informal/everyday language, and the teacher here shows, as Leung argues, that it is possible linguistically to handle sophisticated mathematical concepts across this divide. Likewise, at an epistemological level, such a perspective on language shifts the ways in which knowledge is addressed and meaning is conveyed: as Barwell says in his paper (this volume), from this perspective 'meaning is seen as subjective, situated and in a state of flux'. From the pedagogic point of view, then, recognising the linguistic markers of ambiguity can be a productive way to build students' understanding of mathematical principles and their uncertainty, as opposed to assuming that they simply have to be taught given truths in a categorical and 'correct' way. As Morgan (this volume) also argues the teacher recognises here that the ambiguity they are dealing with in addressing the concept of

'dimension' is not a weakness in the definition, as the NNS 'vocabulary' book implies, but a characteristic of the mathematical concept itself. Rather than helping to 'sort out any ambiguities or misconceptions' the teacher can help learners acknowledge and face up to them – as they will need to do outside of the classroom.

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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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