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CONCEPTUALISING AND RESEARCHING MATHEMATICS CLASSROOMS AS SITES OF COMMUNICATION

INTRODUCTION

In this chapter, I explore the notion of a slight shift of focus from studying communication or use of language in mathematics classrooms to conceptualising mathematics classroom practices themselves as forms of communication. This seems a very minor or pedantic difference, yet I contend that it offers some interesting directions for research that have potential to provide new insights. Fundamentally, rather than seeing language and other forms of communication as things that happen in the classroom, I want to think about classroom practices as essentially taking place discursively. Rather than seeing "Language in mathematics classrooms" as one research topic alongside others such as "Assessment in mathematics classrooms" or "Technology in mathematics classrooms", the theories and methodologies that we use and develop for studying communication in mathematics classrooms move to become tools for thinking about and studying a much wider range of topics.

The significance of language and other semiotic systems in doing mathematics is very widely recognised, whether seen as the way we access mathematical concepts (Duval, 2006) or as the way they are constituted (Sfard, 2008). Not only are the objects or concepts of mathematics encountered discursively but mathematics is overwhelmingly practiced through the use of language and other semiotic systems. In Dowling's terms, the practice of mathematics is discursively saturated, in that the principles of mathematical activity are made available discursively and the practice can thus be carried out relatively independent of any particular material context (Dowling, 1998). Linguistic, semiotic and discursive approaches to studying mathematics classrooms are thus indicated – as well as study of the language, other semiotic systems and discourse used in the teaching and learning of mathematics.

However, school mathematics practices involve more than just doing mathematics. Mathematical content is selected, ordered and transformed according to curricular and pedagogical principles (what mathematics is considered desirable to be learnt by children, how does it need to be presented in order for children to learn, what do children need to do in order to demonstrate that they have learnt). Such principles are manifested in policy documents, curriculum documents, assessment instruments, teacher education encounters, textbooks and so on. The process of construction of school mathematics is thus carried out through successive acts of communication, each of which reflects the interests of the participants.

These interests arise from the fact that classrooms are situated within societal and institutional contexts that shape the social relationships among the participants. These social relationships are also to a large extent realised through language and other means of communication. Institutional expectations about the roles to be played by teachers and by students shape and are shaped in classroom communication, governing who may speak, what kinds of things they may say, how they may speak and to whom. Understanding teaching in mathematics classrooms demands that we study these non-mathematical components and the relationships that these may have with the mathematics that students may learn (Morgan, 2014).

I will generally refer to 'communication' rather than 'language' because it is important to remember that mathematics teaching may make use of a wide range of communicational modes, including specialised mathematical notations, various forms of visual images, gesture and other bodily forms of communication, information and communication technologies, as well as spoken and written language. The implications of considering multiple modes of communication rather than focusing solely on verbal language are discussed more fully in Morgan, Planas and Schütte (Chapter 1). In the next section of this chapter, I discuss some theoretical considerations and the theoretical resources that I draw on in order to research mathematics education from this perspective. I then consider how some fundamental questions about mathematics education might be reformulated and elaborated from this perspective. Finally, I outline and illustrate some analytic approaches.

THEORETICAL RESOURCES

In thinking about communication and mathematics classrooms the first theoretical issue that needs to be addressed is how to conceptualise the relationship between 'what is said' and 'what is spoken of' – between the word and the world. Consistent with my wish to conceptualise teaching as communicating, I choose not to separate the word from the world. I do not deny that there is a material world and that this constrains our experiences but our experience of materiality is also shaped by the ways in which we speak about the world. As Foucault put it, discourses are not just sets of words and other signs that represent the world in particular ways but are practices that "systematically form the objects of which they speak" (Foucault, 1972, p. 49)

While this notion of discourse is an important theoretical frame, I wish to focus attention on the detail of communication within discursive practices – the lexicogrammar, logical relationships and textual structure of language-in-use and the equivalent level of analysis of other communicational modes. My contention is that looking at the detail can provide insight into the concepts, values and possible positionings, actions and relationships that constitute the discursive practice. As Halliday and Matthiessen (1999) argue, the language provides the semantic resources through which we experience the world. To illustrate this point, consider the ways in which mathematics educators may speak and think about classrooms in which the participants speak more than one 'national' language.

Example: Multilingual classrooms or second language learners

Clearly there are differences between people – but only some of these are named and spoken of as significant in relation to language in mathematics classrooms. One difference of concern to many mathematics educators, including several of the authors in the current volume (see, in particular, Moschkovich (Chapter 4), Planas & Chronaki (Chapter 5), and Rangnes & Meaney (Chapter 12)) is difference in the 'national' or 'home' languages used by students and in classrooms. The range of linguistic resources available to an individual or group is a feature of the material world – but this material phenomenon may be spoken of in various ways.

Within the research domain concerned with the presence and use of more than one 'national' language, some researchers speak of bilingual, multilingual or monolingual students or classrooms. Others refer to 'second language learners'. While the first way of speaking orients us to think about the ways that multiple languages may operate together for individual students or within a classroom, the second way of speaking orients us to think about the need that such learners may have to acquire new language knowledge and skills. Such different orientations towards multilingualism have already been discussed within our field, contrasting deficit models of bilingualism with the idea of multiple languages as a resource for learning (e.g. Moschkovich, 2002; Planas & Setati-Phakeng, 2014) and raising issues about relationships between learning mathematics and acquiring a language that has political or economic power (Planas & Civil, 2013; Setati, 2008). Awareness of the consequences of using one term or another enables us to make an informed and explicit choice about which words to use.

It is important to note that speakers and writers do not generally make conscious and deliberate choices about which words to use. Most of the time we adopt the common ways of speaking within our social context without reflecting on our language practices. It is only when we are aware of alternatives and of the significance of their consequences that we take care in selecting our words. Researchers interested in language and mathematics education may have the awareness and freedom to choose deliberately whether to speak of multilingual classrooms or of second language learners – though they may still not be conscious of how their choices may be interpreted by others. However, choices are not equally available for all or in all circumstances. In particular, it is worth considering how institutional practices constrain choice. Where official policy and curriculum documents refer to 'second language learners', this is likely to be the way of speaking taken up by schools and teachers as they formulate their practices, making it more likely that they will orient their practice to expect such students to acquire the language of instruction rather than drawing on their existing language resources. More generally, if we researchers wish to communicate effectively with policy makers and practitioners, it can be a challenge to reconcile our messages, developed within the research domain, with the words of policy and practice. As soon as you change the words you change the ways in which the messages will be heard.

Communication as making functional choices

Thinking about choice brings me to the first set of theoretical and methodological resources I draw on to think about what happens in classrooms: Halliday's social semiotics (Halliday, 1978), the associated tools of systemic functional linguistics (SFL) and developments extending these ideas and analytical tools into the field of multimodal semiotics (Kress & van Leeuwen, 1996; O'Halloran, 2005). From this perspective, communicating using language or other semiotic systems involves selecting from a system of paradigmatic and syntagmatic options. That is, choosing (consciously or not) which words to use and how to connect them with other words in order to form coherent messages. The example above suggested how choices between words (multilingual classroom or second language learners) may affect the ways that teachers, policy makers and researchers orient their practices. Similarly, consider the possible effects of altering the ways such words are combined with others. For example, compare "I teach in a multilingual mathematics classroom" to "My mathematics classroom is full of second language learners". Each of these statements could refer to the same material situation and might be construed as communicating a challenge for the teacher. However, the challenges are likely to be construed differently: attempting, in the first case, to operate effectively as a teacher within a complex environment or, in the second case, to accommodate alien or deficient students into a familiar setting.

A second important feature of social semiotics is that language and other modes of communication are seen as functioning in the world – not simply to convey ideas from a speaker to a listener but to play a constitutive role within social practices. Halliday's categorisation of three metafunctions fulfilled by every utterance orients us to ask how classroom communications function ideationally to construe the objects and logic of mathematics, how they function interpersonally to construe social relationships within the classroom and relationships with mathematics and how they function textually as components of the social practice of the classroom (Halliday, 1978; Morgan, 2006).

When considering the ideational function as it is specialised to enable construal of mathematical objects, relationships and logic, Anna Sfard's (2008) characterisation of mathematical discourse provides useful categories and tools that complement the more comprehensive and detailed grammar offered by SFL and multimodal social semiotics, highlighting the nature of mathematical objects and the forms of reasoning valued in academic mathematics. As has been argued elsewhere (Morgan & Sfard, 2016; Tabach & Nachlieli, 2011), fundamental assumptions of Sfard's communicational theory and social semiotics are compatible, legitimising research that draws on both. Interestingly, Sfard's theory also distinguishes between 'mathematising' and 'subjectifying' functions of discourse, parallelling the social semiotic distinction between ideational and interpersonal functions.

Pedagogic discourse: Participation, social relations and identities

Zooming out from single communicational events to consider longer term participation in the classroom leads me to think about two aims or functions of education in general and mathematics education in particular. Just as each communication event functions to construe the subject matter and at the same time to construe relationships between the participants within the immediate context, so, on a larger scale, the discursive practices that constitute the classroom serve both to induct students to take part in mathematical practices and to guide their acquisition of particular identities, roles and ways of behaving. Just as saying different things or speaking differently provide different possibilities for participants to make meanings about the subject matter and about their immediate relationships with each other, so different forms of pedagogy offer different opportunities for mathematical learning and for students to develop their ways of being. This draws me to Bernstein's (2000) theory of pedagogic discourse.

For Bernstein, pedagogic discourse is conceived as a set of rules governing the transmission and acquisition of knowledge: recontextualisation rules that shape the ways in which academic subject knowledge is selected and transformed for the purposes of teaching and learning; distribution rules that determine who has access to which aspects of knowledge; and evaluation rules that enable judgements about what counts as successful learning. Each of these rules can be formulated in terms of discourse. Recontextualisation is a process whereby a discourse produced in the academy – the mathematics produced by university mathematicians – is brought into a new context in which it comes in contact with other discourses, including, for example, educational discourses produced in the fields of psychology or philosophy, policy discourses and everyday discourses about children, schools and mathematics. A new discourse of school mathematics is brought into being by selecting from this diverse set of discursive constructs, principles and ways of speaking, transforming mathematics for the purposes of schooling. Distribution rules control who is able to access and participate in various forms of mathematics discourse. Studies of the discourses of school mathematics textbooks and classrooms have shown differential access to highly valued forms of academic mathematics discourse made available to students of different gender, social class and perceived 'ability' (Atweh, Bleicher, & Cooper, 1998; Dowling, 1998; O'Halloran, 2004; Straehler-Pohl, Fernández, Gellert, & Figueiras, 2014). Evaluation rules determine what counts as successful participation in mathematical discourse. Students need both to recognize the desired forms of discourse and to access the realisation rules that enable them to produce legitimate texts themselves. Different forms of pedagogy make use of different kinds of criteria (whether performance of specific tasks or display of general competences or personal characteristic's) and make the criteria for successful participation more or less explicit.

Just as, according to social semiotics, any text performs both ideational and interpersonal functions, Bernstein argues that the instructional discourse – that is the mathematics that is to be learnt – is always embedded in a regulative discourse – that is the rules of the social or moral order: "the forms that hierarchical relationships take in the pedagogic relation and […] expectations about conduct, character and manner" (Bernstein, 2000, p. 13). The 'content' of mathematics classroom communication cannot be separated from the social relations of the classroom itself. Like social semiotics and Sfard's communicational theory, Bernstein shares the rejection of both a fixed word-concept relationship and of any dualist separation between language and the content of communication. At the same time, all three theoretical perspectives conceive of communication and discourse as playing roles in construing both the subject matter of the communication and the identities of the participants.

While social semiotics emphasises choices that are made as individuals contribute to communicative events, Bernstein's emphasis on rules provides us with a focus on the social structures and norms and the interests of agents in particular fields of activity, all of which play a role in shaping the conscious or unconscious choices made by participants and the ways they construe communications. The three perspectives thus offer complementary and compatible constructs and tools for investigating classroom practices as communication (see Hasan's (2002) discussion of the complementarity and compatibility of the theories of Halliday, Vygotsky and Bernstein).

POSING QUESTIONS

This conceptualization of classroom practices as communication prompts the formulation and reformulation of a number of questions about classrooms that are of concern for the field of mathematics education. For a start, the question of mathematical content, "What mathematics is taught in the classroom?" can be reformulated very simply as "What is communicated to students?", considering all the forms of communication, whether directly by a teacher or through other means such as textbooks, technological tools, etc. Drawing on the tools provided by SFL and Sfard, a more precise way of posing this question might be to ask, "What are the characteristics of the mathematics classroom discourse that students are expected to participate in?" (see Morgan & Sfard, 2016), while focusing on Bernstein's evaluation rules as a defining component of pedagogic discourse, orients me to ask, "What are the criteria for successful participation in mathematics classroom discourse?"

Given the space constraints of this chapter, I outline the reformulation of other fundamental questions in Table 1. This set of reformulated questions is neither comprehensive nor definitive; it is intended merely to demonstrate the extent to which studying the forms and functions of communication enables us to seek understanding of the nature of school mathematics experienced by teachers and students and of social relationships within classrooms and wider educational systems.

Table 1. Questions about mathematics classrooms as sites of communication

Fundamental questions	*Questions about mathematics classrooms as sites of communication*
What is the content of mathematics teaching?	What is communicated?
	What are the characteristics of the mathematical/classroom discourse that students are expected to participate in?
	What are the criteria for successful participation in mathematical/classroom discourse?

How may teachers and students relate to mathematics?	How may the participants relate to the subject matter of the communication? Who is able to say what and with what degree of authority?
What are the relationships between teacher and students?	What are the relationships between the participants in the communication?
What kinds of teaching and learning are happening in the classroom?	What modes of communication are used by teachers and by students? What roles do teachers and students play as producers and consumers of classroom discourse?
What makes teaching and learning more or less successful?	What forms of communication facilitate successful participation in mathematical/ classroom discourse?
How does teaching distribute success for different social groups?	What forms of participation in communication are available for students of various social groups? (Of particular concern to many contributors to this volume) What forms of communication facilitate participation in multilingual classrooms?

If we wish to characterize different forms of pedagogy or different types of classroom, an additional meta-level question might be formulated: What are the critical differences in forms of classroom communication (whether in content, relationships or participation) that we may use to distinguish different forms of pedagogy or types of classroom?

Reformulating questions about classrooms into questions about communication makes them susceptible to theoretical approaches that use linguistic, semiotic or discursive constructs such as those I have discussed and their associated methodological tools. Studying the forms and functions of communication enables us to address questions about the nature of school mathematics experienced by teachers and students and about social relationships within classrooms and wider educational systems.

RESEARCHING CLASSROOMS AS SITES OF COMMUNICATION: ANALYTIC APPROACHES

It would not be practical within the scope of this chapter to attempt a comprehensive review of possible research methods consistent with the perspective I have developed. Instead, in this section, I suggest some general methodological principles and then present two examples from my research with colleagues, illustrating a selection of analytic tools and their application.

A focus on communication entails that the object of study for research is text and its production and consumption (by whom and in what circumstances). The term text is used broadly to encompass stretches of language-in-use, where language is taken to include speech and writing but also visual images, gestures – a range of multimodal forms of communication. Crucially, any text is part of a social event and its interpretation (whether by the participants or by a researcher) is inextricably linked to that event and the practice of which it is a part (Fairclough, 2003). Studying a text or set of texts enables us to draw conclusions about the nature of the communicative event and the practice of which it forms a part. However, it does not allow us to draw conclusions about the knowledge, understanding, intentions, emotions or other 'internal' or 'psychological' characteristics of the participants. That is, analysis may tell us what kinds of knowledge are communicated during the event and how the participants in the event are positioned in relation to that knowledge and to each other in the context of the event. It cannot tell us who knows what or what any participant feels or believes.

There is a wide range of analytical tools available for studying text, developed in fields such as linguistics and discourse theory. As such tools have been developed for purposes originating within those fields, their application needs to be adapted by researchers in mathematics education to address the problems, constructs and values of our field. Adaptation may involve: selection of those tools best suited to the immediate research problem; redefinition or addition of new tools to enable analysis of specialised mathematical textual features; interpretation of outcomes of analysis in relation to social practices of mathematics education. Of course, adaptation needs to be coherent with the principles of the original sources. In section 2 of this chapter I have indicated the sources I draw on and in the following examples I illustrate some of the ways in which my work with colleagues has used and adapted analytical tools drawn from these sources. The examples also illustrate directions that research can take from a communication perspective, addressing some of the questions identified in section 3.

Example 1: What kinds of mathematics?

The first example originated from a project in collaboration with Anna Sfard which started with the aim of investigating how school mathematics may have changed over time as a potential contribution to debates about 'standards' (Morgan & Sfard, 2016). From such a starting point, two major methodological issues arose: how can we characterise 'school mathematics' and what kinds of data might provide evidence of change over a period of decades (chosen to encompass critical changes in educational policy and curriculum in England). In the absence of sufficient access to classrooms from thirty years ago, we realised that our data would need to be documentary evidence and chose to use the examinations taken by almost all students at the end of compulsory schooling. The high stakes nature of these examinations is known to have a strong influence on classroom practice. Moreover, assessment practices instantiate the evaluation rules which, according to Bernstein, "condense the meaning" and the purpose of the pedagogy (1996, p. 50). Hence, examinations would provide a valid, though by no means complete, window onto students' experience of school mathematics.

One major focus of our investigation was on the nature of the mathematical knowledge and activity that students were expected to engage with, both as 'consumers'/ readers of mathematical text and as producers. The small example discussed below illustrates how thinking about examinations as communication and focusing on the linguistic characteristics of that communication can inform our understanding of the content of school mathematics and of how students may come to relate to it. One of our concerns was with what Sfard terms the alienation of mathematical discourse – the presentation of phenomena "in an impersonal way, as if they were occurring of themselves, without the participation of human beings" (Sfard, 2008, p. 295). The analysis revealed a further source of alienation: communication that not only obscures who acts but also removes the actions themselves. Our consideration of actors and actions makes use of Halliday's distinction between types of processes, in particular the distinction between material processes, which involve an agent doing an action (possibly to another actor), and relational processes, which do not involve agency but ascribe an identity or a property to an actor (Halliday, 1985). The full analytic scheme, drawing on both social semiotics and Sfard's communicational theory, is presented in Morgan & Sfard (2016).

To see how choices between types of process may affect alienation, consider the similarities and differences between the following statements, describing the same geometric figure:

1. I drew a line through point C perpendicular to the line AB, so that it meets AB at point P.
2. A perpendicular line has been dropped from C to the line AB, meeting AB at point P.
3. Line CP is perpendicular to line AB.

In statement 1, the human agency in doing mathematics is explicit: *I* acted in a material process (*drew*) that constructed a new mathematical object with certain properties. In statement 2, the use of the passive voice (*has been dropped*) is a source of alienation, obscuring the participation of an agent. Nevertheless, the material process of dropping implicitly entails the existence of an agent of some kind, including the possibility that this agent was human. Both these statements describe a process of construction of the figure; it has come into being as a result of an action. Statement 3, however, involves only a relational process (*is*), ascribing a property to line CP; without any material action, there is no space to construe human agency. Moreover, there is no suggestion that there might have been a time before the line CP existed.

To illustrate the application of this analysis to our data set, I compare two items taken from examination papers set in 1987 and in 2011. Both items are concerned with the properties of geometric figures and each starts with a diagram (not reproduced here), which is then described in words. Analyses of agency and processes for the verbal descriptions of the diagrams in items A and B are summarised in Tables 2 and 3 respectively. A fuller analysis of the two items is given in Morgan (2016).

In item A, the mathematical objects are involved in material processes – the statements are mainly about doing (*touching*, *meeting*, *producing*). There is just one relational statement ascribing a measure to the angle. Although no human agency is apparent, mathematics is construed as an active process, taking place in time.

Table 2. Item A (University of London Examinations Board, 1987) - agency and processes

Figure 2 shows a circle with a chord AB and a tangent AT touching the circle at A. The bisector of angle BAT meets the circle at P and BP produced meets AT at Q. *Angle PAQ is x°*		
	Agency	**Process type**
Figure 2 shows a circle	representational object *Figure 2*	verbal *shows*
a chord AB and a tangent AT touching the circle	mathematical object *a chord AB and a tangent AT*	material *touching*
The bisector of angle BAT meets the circle	mathematical object *The bisector of angle BAT*	material *meets*
BP produced	obscured (passive voice)	material *produced*
BP produced meets AT	mathematical object *BP*	material *meets*
angle PAQ is x°	-	relational *is*

Table 3. Item B (Edexcel, 2011) - agency and processes

In the diagram, *ABC is a triangle,* *Angle ACB=90°,* *P lies on the line AB,* *CP is perpendicular to AB.*		
	Agency	**Process type**
ABC is a triangle	-	relational *is*
angle ACB = 90°	-	relational =
P lies on the line AB	mathematical object *P*	material *lies*
CP is perpendicular to AB	-	relational *is*

In contrast, Item B presents a sequence of agentless, a-temporal relational statements. Even the one material process lies suggests little action, in effect describing the position of point P rather than the action of positioning itself on the line. Extensive use of relational processes is characteristic of much scientific writing and plays an important role in enabling some forms of scientific and mathematical reasoning. At the same time, this and other sources of alienation are much less common in everyday speech. They serve to conceal the activity that generates mathematics, construing “a world made out of things, rather than the world of happening – events with things taking part in them – that we were accustomed to” (Halliday, 1993, p. 82). In the context of school mathematics, this raises questions about how students may position themselves in relation to mathematical activity when the form of communication obscures the ‘happening’ of mathematics.

It is worth noting that Item B contains other discursive features that may be seen as less characteristically mathematical. Each relational statement is simple and discrete with no explicit logical connections – the sequence is descriptive rather than analytic or argumentative. The specialised vocabulary is very limited. Some of the changes between 1987 and 2011 may have been made in a deliberate attempt to make the language more accessible to a wider range of students. We might then ask to what extent the ways language is used actually provide students with access to high status mathematical activity – apprenticing them to mathematical discourse (Dowling, 1998).

Example 2: Classroom assessment

The second example is drawn from work I have been developing together with Lisa Björklund Boistrup. It originates from a joint interest in assessment as an important (and under-studied) component of classroom practice and builds on Lisa's doctoral study (Björklund Boistrup, 2010) which identified different kinds of feedback (and 'feed forward') provided to students in primary classrooms. Following Bernstein, we see assessment (referred to by Bernstein as "evaluation") as the key to understanding pedagogy and the way it acts to shape learners:

> Evaluation condenses the meaning of the whole [pedagogic] device. … The purpose of the device is to provide a symbolic ruler for the consciousness (1996, p. 50).

At this stage, we are concerned to develop a framework for conceptualising and analysing classroom assessment, drawing on the theoretical perspectives that I have discussed in this chapter.

Our focus is on what we call assessment episodes – defined as interactions in which there is communication, whether explicit or implicit, about one or more success criteria between a teacher and a whole class, group or individual student. The interaction may be face-to-face or may be mediated by written texts such as textbook tasks or children's written answers. Such episodes include formal events such as marking homework or test preparation but also informal feedback such as praise or advice. We have observed in earlier empirical work that there is variation in the types of criteria that teachers use, in the consistency with which these criteria are applied and in the ways they are communicated to students (Björklund Boistrup, 2015; Morgan & Watson, 2002). Our concern is to systematise a way of describing and identifying this variation. Using assessment episodes extracted from Lisa's doctoral data[1], we have focused on the criteria that are communicated and the ways that these are communicated, considering the mode of communication (in particular, speech, writing, gesture, gaze and facial expression) and its modality (communicating relationships between the participants and to the subject matter). We also consider whether criteria are explicit or implicit, drawing on Bernstein's distinction between visible and invisible pedagogy.

This first extract comprises two assessment episodes. In episode 1a, both children and teacher identify a number as the correct answer to a given task. This is approved by the teacher (T) with gesture and facial expression. Episode 1b follows immediately. Here, the teacher responds negatively (by facial expression and by further questioning about the method) to the child's claim that the correct answer was achieved by guessing. Ali seems to recognise that guessing is not an approved legitimate method as he admits "We just guessed". The use of just reduces the value of the method. In the final line of the transcript we see Ali attempting to position himself more positively by reclaiming success according to the first criterion (having a correct answer), while Ang recognises failure and displays negative affect.

Episode 1a: An answer

S: Then we have come to Ali (S): that *this* is the answer!	Ali (S) points at a number on the paper.	Ang (S) looks at the paper. Ali (S) and T look at the paper. Ali (S) and Ang (S) look at T.
	T holds up her thumb to students.	T smiles.

Episode 1b: A method

[T: Very good. [Ali (S): We just guessed.	T moves her hand with the cards upwards. Stops moving hand.	T looks at the paper in her hand.
T: You did?		T stops smiling and looks at Ali.
Ang (S): Yeah.		

[1] Data originally in Swedish, translated by Dr. Björklund Boistrup.

T: I think. Have you guessed *all* the way?		T looks mostly at S1 and S2. Ali stops smiling.
[Ali (S): Well, we solved it. [Ang (S): No, we	Ali waves with his hand.	 Ang looks up (in the air), stops smiling.

The next example, episode 2, is a written interaction comprising written feedback by the teacher on a piece of student work.

Episode 2: A format for answering

[written by the teacher on a student text]
"Use the squares [on the paper] to make it easier to make a number axis"

The use of squared paper is an institutional convention of primary school mathematics in Sweden. In this case, the student had drawn a number line with an evenly distributed scale but had not aligned the line or the number scale with the squares printed on the paper. Although the teacher claims that using the squares "make[s] it easier", it is not evident that the student had any difficulty with drawing a number line that was adequate for achieving correct answers to the given task of marking the position of specified numbers on the line. Indeed, the teacher marked the positioning of the numbers as correct. It seems, therefore, that her remark refers to an implicit criterion about the form of the drawing (that it should be neat and use straight lines), which can be supported by the squares on the paper, rather than to the mathematical task of ordering numbers.

My final example is an episode drawn from a written self-assessment task[2]. In Episode 3, the criterion children are asked to use to assess themselves is not their level of competence or achievement in the given mathematical skill but their level of certainty or confidence – a personal characteristic that is not necessarily directly related to competence or mathematical achievement.

Episode 3: A behaviour or way of feeling or being

When I am supposed to:	I feel:		
	Certain	Quite certain	Uncertain
explain the difference between a digit and a number		X	
draw a picture of the number 4,312		X	
read the number 4,030	X		

While the instructional and regulative discourses are in principle inseparable (Bernstein, 2000), the four types of criteria evident in these episodes differ in the extent to which the instructional discourse (the mathematics) or the regulative discourse (the moral order) is prioritised. Thus, according value to *a mathematically correct answer* (Episode 1a) seems to prioritise the instructional, expecting *a specific method* (Episode 1b) introduces moral as well as mathematical values, *neat presentation* (Episode 2) further prioritises moral values although mathematical value may also be claimed, while valuing a child's *confidence* (Episode 3) prioritises the regulative.

In cases where the instructional discourse is prioritized, we might further consider the nature of the mathematics that is valued. For example, drawing on Sfard's (2008) characterization of mathematical discourse, it would be possible to ask whether ritual or exploratory routines are valued and to consider the nature of the narratives that are endorsed during an assessment episode.

An important aspect of our interest in classroom assessment lies in the distributive rules of the pedagogic discourse. That is, the ways that the pedagogy structures student access to the instructional discourse. In particular, we ask how the characteristics of communication during assessment episodes, especially the characteristics of teachers' contributions, may differ between students or groups of

[2] It is worth noting that this self-assessment task was included in the textbook material and was inspired by elements of the Swedish national tests. It may thus be considered an 'official' component of the pedagogy.

students and whether any such differences can be associated with student characteristics such as gender, ethnicity, class, perceived ‘ability’, etc. Initial consideration of the extracts of data suggest that possible dimensions of difference worth investigating include:

- the prioritisation of instructional or regulative discourse
- the extent to which evaluation criteria are made explicit
- use of specialised mathematical language or everyday language (and shifting between them)
- the ways a teacher responds to initiatives from students.

FURTHER DIRECTIONS

I have suggested reformulating questions that conventionally reside in other domains of mathematics education research in terms of communication. While I would not wish to be such an imperialist as to suggest that this is the only or even the best way of addressing mathematics classroom practices, I believe that conceptualising classrooms in terms of communication opens up possibilities for drawing on theoretical approaches that offer useful insights and methodological tools that enable us to construct systematically theorised approaches to the analysis of qualitative data. The theoretical resources and methodological approaches presented in this chapter illustrate the potential of such a conceptualisation. Other resources from fields such as linguistics, discourse theory, philosophy and sociology may offer further approaches to studying classrooms as sites of communication. There is certainly scope to explore such resources, the research questions they generate, the conceptual and analytic tools they provide and the insights that they may offer to the field of mathematics education.

A further issue that I have not addressed in this chapter is the possibility of using insights arising from a focus on communication in order to engineer changes. As suggested in discussing the first example presented above, attempts to ‘simplify’ the language used in an examination item or to present tasks in multilingual classrooms may change the way the mathematics is construed as well as changing the reading difficulty. Changes in communication practices do not necessarily have simple or predictable consequences but offer important sites for research (Tabach & Nachlieli, 2011).

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