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MAKING SENSE OF MATHEMATICAL LANGUAGE IN A PRIMARY CLASSROOM

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From an analysis of classroom dialogue in three British mathematics lessons and eight structured interventions with Year 5 children (ages nine and ten), my research highlights several issues affecting the shared understanding of meaning. Mathematical language is far from precise in meaning, and communicative processes are often tentative and transient according to the particular situational context. In particular, references to everyday contexts do not necessarily help the communicative process when teaching and learning the concept of probability in the primary school. Few life events have certainty, or an 'even chance'. Gestures and pictorial images are also influential when trying to communicate one's understanding of meaning.

INTRODUCTION

The requirements for initial teacher training (TTA, 1998) used the word 'precise' in their description of mathematical language and its use. From my own experience, the learning of mathematical language is more complex than the document implies. A tension exists between the idea of a precise language, and the multi-faceted nature of the mathematical concepts that the language describes and explains (Pirie, 1997). I am interested in the effects on shared understanding of 'contextual references' that teachers and children make, when trying to explain ideas. A contextual reference is a reference to a *physical situation* or a *mental representation* of such.

I chose the phrase 'even chance' for analysis, because the teacher taught a whole lesson about this concept and the children provided a variety of explanations to exemplify their understanding. Many primary school mathematics texts use the term 'even chance' to describe a prediction that places an event halfway along a probability scale of impossible to certain. Primary school teachers might also use 'even chance' to describe the possible outcome of an event with two equally likely outcomes. In an everyday context, however, one might use and interpret 'even chance' in a more vague manner, for example sometimes it is used to replace the phrase 'equal chance' or the 'same chance'. My purpose was not to determine whether the phrase 'even chance' was appropriate or acceptable in primary mathematics classrooms. It was the phrase presented in the mathematics textbook and used by the teacher, in a 'typical' primary classroom situation, and thus it was my focus. My purpose was to analyse dialogic practices used by the teacher and the children when they explain the meaning of the phrase 'even chance' and other mathematical words.

RESEARCH QUESTIONS

The investigation of contextual references used to describe meanings of specific mathematical words in a particular school setting is sociolinguistic in nature.

Sociolinguistic research studies the relationship between the language and the situational context in which it is used. Current linguistic research focuses on observing participant dialogue and the development of shared understanding of meaning. I took a linguistic approach to studying the language with a focus on description, in relation to the function of conveying meaning. Thus, my research was of the pragmatic rather than the semantic nature of language. My aim was to analyse classroom discourse to discover the ways in which teachers and children share the meaning of specific mathematical words in different settings. I also used 'interpretive' methods as a primary mathematics education specialist applying my knowledge of primary mathematics teaching and learning to the data I collected (Graue and Walsh, 1998).

I involved only a few subjects providing detailed observations. I was particularly interested in exploring contextual references occurring in discourse during explanation and exemplification of mathematical words. The contextual references are a pseudo-social context, to which participants refer, particularly if they refer to real-life events. In this sense, the contextual reference might also become part of the immediate social setting for the dialogue, e.g. a child drawing trains on a railway line to show 'even chance'. The project had two interrelating research questions exploring both *teaching* and *learning* with the intention of informing classroom practice.

Research question 1: How does the teacher interact with the children to develop a shared understanding of the meaning of mathematical words?

Research question 2: How do children express their understanding of the meaning of specific mathematical words and phrases?

LITERATURE

I developed a conceptual framework for my research with reference to a range of perspectives but particularly including ideas from social constructivism in mathematics education, psychology and linguistics. I looked at the work of Piaget and Inhelder (1975), and others on the development of probabilistic concepts and language. As 'context' influences the 'potential to make meaning shareable' I also tried to address some of the complex and interrelated issues about what is meant by 'context' in this study.

Research into children's understanding of probability tends to focus on conceptual rather than linguistic development. Piaget and Inhelder (1975) used the children's oral responses to identify their stage of conceptual development. They made a judgement about the quality of each response in relation to the question asked. They did not expect the children to use mathematical words, but to explain their thinking in their own words. The concern with programmes for teaching probability to primary school children (ages five to eleven) appears in recent research. Jones, Langrall, Thornton and Mogill (1997) developed a framework for assessing and developing children's probabilistic thinking. They expected children at different levels to know and use the same words, but with different levels of meaning for them. Jones et al. (1997) considered that recognising 'certain' and 'impossible' was the starting point for probabilistic thinking. Earlier research had questioned the ease at which children identified probabilities of certitude (Fischbein, Nello and Marino, 1991). Fischbein *et al.* found that children found it easier to identify events that were possible, rather than certain. They commented on the nature of events affecting responses, and that the nature and language of questions asked about events influenced children's responses. It seems from such research that although the researchers were not focusing on language or dialogic processes *per se*, there is clear indication that linguistic factors are important in the development of probabilistic concepts.

METHODS

I observed three lessons consecutive lessons on probability, using video recording to capture evidence of the main teaching input, with occasional narrative recording of pupil-pupil or teacher-pupil interaction during class work. I collected some samples of written work that involved children explaining their reasons for allocating probabilities to given events. After watching the video recording, I developed a questionnaire for the teacher, who also watched the video recording before responding to my questions. Informal discussion clarified my understanding of his responses. For the structured interventions sixteen children, eight mixed gender pairs, chosen by the teacher used a series of sheets to encourage discussion about probabilistic language. This also provided written and video evidence. Data collection was an important methodological issue, but just as important was the nature of the transcripts that documented the lesson's character to identify the nature of interactions that occurred. The video camera helped to retain objectivity by providing a record to revisit and check compatibility of the dialogue with classroom events when transcribing. It was also important to add information to transcripts of dialogue such as perceived communication and control relationships that provided depth of analysis later. In total, there were approximately seven hours of video evidence for transcription. Once transcribed, I used discourse analysis in both strands of my research. In the classroom observations the focus was on dialogue between the teacher and the whole class, while in the structured interventions the focus was on peer interaction with researcher intervention. My aim was to identify the ways that both types of dialogue contribute to participants shared understanding of meaning of mathematical vocabulary. The actual process of discourse analysis derived from work by Mercer (1995) who identified various types of reformulations occurring in classroom dialogue. Initially I developed a coding system to help my analysis, as suggested by Potter and Wetherell (1995). However, I found that the system I developed during the first transcript required modification as I worked with further material.

SUMMARY OF FINDINGS

My transcript data is too extensive to include here, but is contained in the full thesis deposited at the Open University (Bold, 2000 unpublished). I present here the key points identified from the transcript data and the teacher's questionnaire responses that provided validity for my observations.

During the first lesson, the teacher revised probabilistic language. His responses to the children's suggestions altered the contextual references thus altering the meaning to 'his' meaning and to make it potentially shareable with the class. He used pictorial images alongside verbal contextual references that had the potential to restrict the transferability of the meaning of a word across different contexts. The teacher had difficulty with controlling the 'open' dialogue because of the children's subjective responses. In the second lesson, the teacher decided to focus on one phrase in order to reduce the ambiguity, but there was evidence that the use of different phrases e.g. fifty-fifty, with the same meaning and the use of different contextual references by the children e.g. a football tackle, still created ambiguity. His closed questioning technique might lead to the development of a narrow definition of even chance that is not transferable across contexts. Numerical comparisons and experimental situations were much easier for the teacher to discuss with the class than 'real life' contexts, and the potential for sharing the same understanding of meaning seemed greater. However, the teacher used different gestures, possibly sub-consciously, to exemplify the meaning of two different labels for 'even chance', thus creating the potential for different understandings of meaning developing in the class. He used gestures that suggested balance, evenness, symmetry and either/or situations. The third lesson focused on the probability scale that the children likened to a 'time line'. This image might negate the understanding of the scale as a continuum with limits, from impossible to certain. The placement of 'real-life' events on a probability scale was difficult because of subjective application by the children, and because too many variables existed making causal justification problematical. A child used the rocking gesture, introduced by the teacher in the second lesson, and there was evidence that some children had difficulty describing their understanding the meaning of 'even chance' in relation to placing it at a particular point on the scale.

During the structured interventions some pairs of children were more able, or willing, to enter an educated discourse than others. A willingness to enter into peer discussion did not necessarily support the development of a shared understanding of meaning. Non-verbal communication i.e. gesture, drawing or both, was an important communication strategy for some pairs. The images suggested by gesture and drawing did not appear very useful in developing a shared understanding of meaning of probabilistic language. The gestures used, and drawings produced for 'even chance' generally suggested balance, evenness and equal shares. Some of the children's reasoning showed that they might have a perceptual view of 'even chance' as equal measures, or numbers. References to 'real-life' events were not useful for developing a shared understanding of meaning, and did not develop children's probabilistic reasoning skills effectively. The experimental work in the second lesson possibly led to some children applying numerical reasoning inappropriately. The children did not refer to a probability scale when discussing 'even chance' and children who had little understanding of the meaning of 'even chance' as two equally likely outcomes could not communicate this effectively through the contextual references they made.

IMPLICATIONS FOR TEACHING AND LEARNING

My first recommendation relates to current British curriculum guidance that suggests using everyday events for teaching probability (DfEE, 1999). I would extend this to suggest primary teachers should choose everyday events for which there is a likelihood of two equally likely outcomes, when discussing 'even chance'. Examples of events found in texts are not necessarily easy to predict e.g. the chance of seeing a rabbit on a walk in a wood. The other issue is perceptions of the probability scale. Children tend not to understand it as a continuum. Therefore, my suggestion is to use the scale as recommended in curriculum guidance, as the main pictorial representation and to ensure that primary school children learn that the set of labels placed along the probability scale are points on a continuum from the fixed category 'no chance' or 'impossible' at one end, to 'certain' at the other. 'Even chance' has a central position on this scale.

Peer discussion was most effective when it included cumulative exchanges as described by Mercer (1996), because disputational talk and exploratory talk appeared to cause more ambiguity that the children could not resolve. Teachers or other adults need opportunity to clarify ambiguity arising in peer exchanges when predicting the outcomes of events. Learning probabilistic language appeared closely associated with learning probabilistic concepts. I did not set out to explore this relationship, as I was focusing on the communication processes, but eventually, through analysis, the necessity to use the words clearly in relation to the mathematical concept became evident. Some children relied heavily on gesture to describe 'even chance' and seemed less able to describe it in words alone, so the gesture had a clear communicative function as described by McNeill, (1985). The children's discussions, drawings and writing suggested that their perceptions might negate making sense of the nature of a probability scale as a continuum with fixed parameters. It is therefore important that teachers regard gesture as an important communicative event, especially when children are trying to explain their understanding of mathematical words and concepts.

From my work, I have determined that we cannot talk about a precise mathematical language, but we might consider the notion of 'precision in use' i.e. correct use in relation to the mathematical concept and current context. For example, the earlier reference to 'seeing a rabbit in a wood', requires children to have data by which they can justify their prediction. The prediction of 'even chance' can only be used in a precise way here if the data shows that there is an equally likely chance of seeing a rabbit or not seeing one. Mathematics educators need to explore the meaning of 'correct use of mathematical language' in relation to children learning both the language and the mathematical concepts. My research has highlighted that poor development of ideas about probabilistic language is likely to be associated with poor conceptual development e.g. if a child imagines 'even chance' as an equally balanced bucket scale this may affect further conceptual development when moving on to working with fractional quantities as predictions. I recognise that such a small sample cannot be generalised, but the findings might resonate with observations made in other primary classrooms. It certainly raises some questions that warrant further investigation about the emphasis placed on probabilistic language and subjective predictions at primary level, before children move on to numerical predictions at secondary school.

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