DEVELOPING A FRAMEWORK FOR ANALYSING CHILDREN'S LEARNING OF MATHEMATICS INSIDE AND OUTSIDE THE CLASSROOM

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Analysis of classroom data collected while observing children learning addition in Reception and Year One classes identified the need to describe the relationship between children's understanding and learning of mathematics inside and outside of the mathematics classroom. In this paper I show the development of a framework which allows me to make sense of such relationships, which in turns allows more detailed analysis of the children's learning. This analysis shows young children making sense of their mathematics learning in and out of the classroom, challenging an understanding of learning as 'situated'.

INTRODUCTION

This paper describes the development of a framework to describe and analyse the relationship between children's learning of mathematics and the social context within which they learn, both within and outside of the mathematics classroom. In the twentieth century the curriculum in British primary schools, and especially the mathematics curriculum, has been heavily influenced by Piagetian constructivism (Walkerdine, 1984). Sociocultural (Lerman, 1996) and Social Practice theories (Lave, et al. 1991) while influencing views of learning in primary education (Wood, 1998) have had little observable effect on the mathematics curriculum.

Yet such constructivist studies have tended to ignore the social context of learning which can influence the sense children make of school learning (Donaldson, 1978). Sociocultural perspectives emphasise the development of higher order psychological (or mental) functions which arise from social interaction through the mediation of tools and signs, "processes such as deduction and understanding, evolution about notions of the world, interpretation of physical causality, and mastery of logical forms of thought and abstract logic" (Vygotsky, 1978, p 79). Lave (1991) argues that learning is carried out within communities of practice (school, home etc.) recognising the social nature of learning but at a local level. Such social practice theory suggests that transfer of knowledge from one social practice to another is difficult; knowledge is situated in practice. Nunes' work with Brazilian street children would seem to support this view (Nunes Carraher, 1991). Nunes describes how children, who had competent strategies for calculation when selling fruit in the street markets, were unable to make the same calculations in the school setting, resorting to half learnt formal algorithms. She

concludes that the children held different understandings of the mathematics, which were tied to the situation in which they occurred, and had little or no transference. This appears to confirm understanding as situated in practice, and poses a challenge for teachers, since the main purpose of school learning is its application outside the classroom.

In contrast, Hughes and Greenhough (1998) found that children were able to make links between similar activities carried out at home and at school. The children played games with the teacher at school, and with parents at home, each time being observed by the researcher. Two different forms of the game were used which contained the same mathematical ideas but set in a different context. The study found that the children could recognise the mathematics and use the same mathematical strategies to play the game, and conclude that transfer from one community of practice to another is possible. While I question whether these could be considered separate, rather than overlapping, communities of practice since the activities shared similar purpose and goals, and the researcher and child were present in each, the teacher and school being replaced by the parent and home, the situatedness of school knowledge requires further consideration.

However none of these three perspectives appear to offer insight into the sense that children are making of their whole mathematics learning experience within and outside the classroom.

CONTEXT

The research is part of a wider study which examined the teaching and early learning of addition in early primary classrooms in Britain. The relationship between teaching and learning was examined at the level of classroom interaction, in the carrying out of mathematical tasks. The mathematics lessons of two classes in each of two schools were observed over a period of six months, involving four teachers and 112 children aged 4 to 6 years. The mathematical focus of the study was the learning of addition, one of the first formal mathematical concepts taught in school. This formed a basis for exploring the factors involved in the teaching of mathematics to young children, and their learning.

The methodology was qualitative, with participant observation the main method of data collection. Detailed fieldnotes were taken of all mathematics lessons observed; short unstructured interviews with teachers were carried out before and after the lessons. The children's understanding of number concepts and addition was assessed at both the beginning and the end of the observation period through a series of informal activities and games. The data was analysed using a grounded theory approach, which produced patterns of recurring variables. Analysis of these variables, grounded in the theoretical framework of the researcher, provided analytical pictures of teaching and learning, from which the findings emerged.

ANALYSIS OF THE DATA

Analysis of the data identified 'critical incidents' connected to the relationship between the children's mathematical learning and the social world of the child within and outside the classroom. I therefore sought a framework which would allow me to describe these relationships. Lerman defines critical incidents as

> ones that provide insight into classroom learning and the role of the teacher, ones that in fact challenge our opinions and beliefs and our notions of what learning and teaching mathematics are all about (p. 54).

For me, critical incidents were occasions where something happened which first demanded my attention and then provided such insight. Many of these arose out of observation of the episode itself, and were highlighted in the post-lesson discussion with the classteacher. For example in the following transcript describes part of a lesson in a Reception class. Jacob is two months short of his 5th birthday. The children had been playing a game involving ten children on a bus, involving number bonds of 10, and were recording their work.

Beth:	Jacob, read your 'sentence' out to me.
Jacob:	Eight and two altogether makes ten. We're learning about ten.
Beth:	What do you know about ten?
Jacob:	If you are ten you can run faster than me, because you know Martin who comes and sees me sometimes, he's ten and soon he is going to be eleven.

Beth and I were both surprised at Jacob's observation "we're learning about ten". It showed insight into his understanding of the mathematical content of the lesson; he could have said 'we're learning about buses', or 'children'. However, we were also surprised by his following observation, expecting an answer such as 'you can make ten in lots of different ways'. Instead, Jacob draws on his knowledge of ten outside of the classroom, at the same time showing evidence of his ordinal understanding of number in the context of birthdays. Jacob is making links between his mathematical understanding within and outside of the classroom and this incident was by no means an isolated example, I therefore needed a framework within which to locate these ideas.

DEVELOPING A FRAMEWORK

Strauss and Corbin (1998) describe how, in order to build theory, it is necessary to

> "understand as much as possible about the phenomenon under investigation. This means locating a phenomenon contextually..." (p. 181).

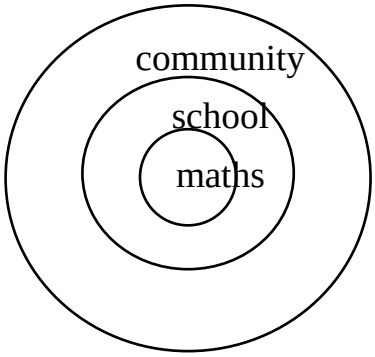
The process of locating results in the construction of a conditional/consequential matrix, which attempts to put together the micro and macro conditions of the phenomenon.

Strauss and Corbin argue that

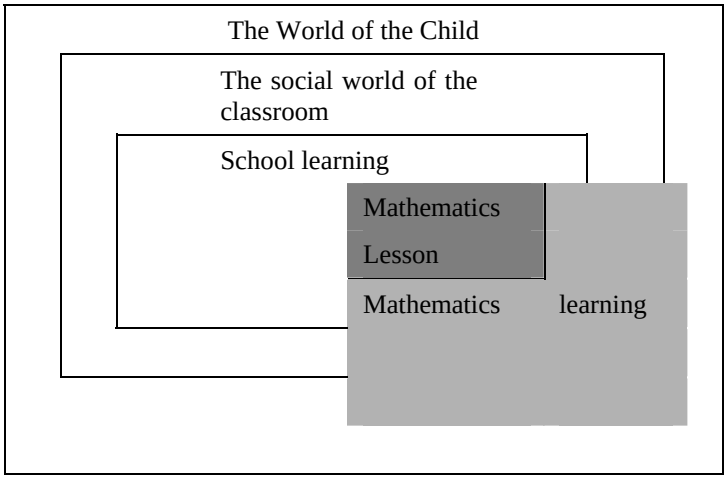
> "events that occur "out there" are not just interesting background material. When they emerge from the data as relevant, they too should be brought into the analysis. Sorting all this out is where the matrix is helpful" (p. 183).

I first considered alternative frameworks which might help. Pollard (1997) working from a social constructivist position provides a diagram which locates the pupils' and teacher's personal factors within the classroom context but does not satisfy the need to describe links between the classroom and the outside world. What I required was a description of the world of the mathematics lesson within the learning community, within the classroom, and within the community, as experienced by the children, on which I could 'locate' mathematics learning.

This reflection led initially to the idea of nesting sets:



which was further refined in the final diagram:



From the children's perspective the mathematics lesson is part of their experience of school learning (remember that mathematics lessons for young children are taught by the same teacher and in the same classroom as all other lessons) which is contained within

their experience of the classroom as a social context, which is itself contained within their 'wider social world'. Mathematics is being learnt and used in all of these contexts contributing to their developing understanding.

FOCUSING IN AND OUT OF THE FRAMEWORK

Development of the framework allowed analysis of other critical episodes which could be located within it. For example, in the following episode from the same reception class during registration, the children are discussing how many children are having different sorts of lunches. This information is recorded on a chart on the wall which shows 8 children having cooked dinners and 16 having packed lunches.

	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	m	m	m	m	m	m	m	m										
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Beth: How many more packed lunches, Charles?

Charles: (counted silently, pointing to the badges to the right of 8 on the packed lunch [top] row) Eight

Beth: So, 16 is 8 more than 8.

Charles: and eight and eight are sixteen.

On its own this exchange may not seem significant. Yet assessment of Charles' understanding of addition had show that of the double numbers he knew only 2 + 2, and his only other addition strategy was to count-all. But here, the context of the discussion, outside of the mathematics lesson, appears to scaffold his understanding, enabling him to show an insight into the additive relationships between number. Mathematics learning is taking place within the social world of the classroom but outside of the mathematics lesson.

There were many other incidents which show, for example, the children's development of cardinal (5 candles) and ordinal (now 10 then 11) number in the context of age, how one child's personal view of winning games overrode his acceptance of the mathematics in the game, and how the children' and teachers' understanding of reading and writing language influence the recording of mathematics, sometimes to the detriment of the mathematical concept.

For each critical incident, the framework allowed me to locate the phenomenon contextually, offering insight into the complexity of the situation. Links could be identified between the mathematics learning and the contexts in which that was taking

place both within and outside the mathematics lesson.

CONCLUSIONS

The framework allows me to look more closely at what is happening in Beth's classroom and analyse the children's mathematical learning, and explains inconsistencies in practice. These explanations offer a theoretical perspective on children's learning which substantiate Donaldson's concept of children making 'human sense' of their learning (1984), and challenge a social practice perspective claim that learning is situated. Children can and do make sense of their school mathematics learning in relation to their lives outside the classroom. The framework therefore offers an important tool for the analysis of children's mathematical learning.

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