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'A number Line in the Nursery Classroom: a Vehicle for Understanding Children's Number Knowledge'

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Introduction

The majority of literature on 3 – and 4-year olds' number knowledge has been heavily biased towards research into counting (Piaget, 1965; Briars and Siegler, 1984; Frydman and Bryant, 1988 and Schrupman and Van Luit, 1995). Hughes's (1986) study found that young children had their won ways of recording numbers that were meaningful to them. Van Oers (1996) demonstrates the importance of a mathematical culture. Gelman and Gallistel's (1978) in-depth research into young children's number knowledge, like many other studies, has disputed Piaget's number conservation tasks that pre-school children lacked certain cognitive abilities. This has moved our thinking about number knowledge in young children on. It has, in many ways, given us a more positive view of young children's number ability. However, there continues to be a dominance of seeing children's number knowledge in terms of errors and minute skills. Fuson (1988) categorised children's attempts at counting into 13 counting errors. This deficit model of children's number knowledge, it could be said, perpetuates the right/wrong view of mathematics, connecting it more to the subject rather than the child's own pattern of development.

Background to the study

What do young children know about number and is it, as most studies suggest, from a counting perspective. As a teacher of young children it is important for me to be able to answer these questions so that I can support their learning. My knowledge of children's literacy development was far greater than my understanding of children's mathematics. The developmental literacy theory has made a great impact on many classrooms. Wells (1987), Smith (1988) and Cambourne (1988) echoed that is was crucial to look at the child, not the subject – what do children know, and not what you think they should know.

The developmental literacy theorists moved away from seeing children's learning in an adult perspective of hierarchical steps. They found that children's learning was more importantly associated with meaning and social contexts, (Clay (1975), Holdaway (1979). They based their methods on following the child in more 'natural' conditions, children choosing tasks instead of set up adult devised situations. It was this model of learning I adopted as a way of observing and supporting mathematical behaviour in the nursery classroom. This article therefore reports some of the research which was part of my M.Ed dissertation at the University of Plymouth. The following is an account of one part of the study that took place in a nursery class of three-and four-year olds. The aim of this part of the study was to look at the classroom environment and the development theory and how it could be applied in a mathematical way.

Methodology

I set up 13 areas in the classroom where the children could freely interact with mathematical materials: my deliberate intent was to enhance the mathematical learning and to observe and support the learning. Observation sheets were put up in every area and I collected an abundance of data, but was surprised that the number line was the most popular area, and second only to the dramatic play area. Although number was only a pat of the focus of the study, the data from the number line area was the most interesting in terms of its link to the development of literacy. Although a number line is not very original and the purpose for the children could indeed be questioned, nevertheless it attracted the children and engaged them in talk and self-initiated activities.

Number lines

There are many different kinds of commercially produced number lines differing in number range and layout. These are often used in schools and nurseries as references for children's number work. Some number friezes have used alternative layout with suggested activities to support children' understanding of number concepts. There are also class-made number lines where the number line is made from a class activity. Moveable number lines, such as clothes pegs with number cards hung on a line or magnetic numbers (Gardner, 1996) are seen as a valuable way of children trying out the number sequence for themselves. The Ofsted Guide for Registered Nursery Inspectors Handbook (1996) specifically mentions that there should be a number line with numerals 1 to 10 in the nursery setting for four-year olds. Number lines are therefore seen as important from many perspectives. Although the rationale or use of number lines is not always clear, indeed the Ofsted document previously mentioned gives no rationale for having a number line or why in particular one should use number 1 – 110 say instead of 0 – 15 or 2 – 30. Pre-school teachers could indeed put up a number line because that is what is required by Ofsted, but have little understanding of its relevance in their setting.

The development of the number line

The number line was placed to grow in accordance with the children's interest. This was going to be a touch and feel number line and the numbers would probably be approximately half the height of a four-year old.

I started the number line by talking to a group of interested listeners about the idea of a number line. I explained what it was. "What number would we start with?" I threw the question open. They decided number three. They probably know more about three than most other numbers: some of them were three, so we started off with a very personal number. Several kinds of materials were gathered so that the children could choose what they were going to put on the number. I drew and they, with help, cut out the number. They chose pasta and spread it over the number and spread it over the number and thus the number line began. It took two months to accumulate numbers to ten, but it was extended because of child interest. At one point zero was put up because there was a space next to the one and that prompted discussion. Each time a group chose a number they had to estimate where it would go in relation to the other numbers. We had to leave spaces for the numbers not yet chosen. Personal numbers were first chosen. For example, after three, four was chosen (the age of some of the nursery children and others who were going to be four). Eight was chosen by Toby whose brother was eight. Toby loved to feel that number and showed his mother that number.

Each number was made from a different material – fur, shiny paper, balloon material, kite material and bottle tops. The numbers became very appealing and interesting to the children. They were at the children's height and steps led up to them. Twenty-seven children responded to the line. Three of them only touched and felt it, the rest interacted with other children and extended their experience: counting and touching, talking with each other about the numbers, measuring, cardinal and ordinal value. Amy initiated a circus game. She asked the children she was playing with to stand next to a number and the children jumped down as arranged by Amy. They jumped down and found another number. Amy was not always correct in her naming of the numbers but other children were able to help her and in some cases Guy said the number he was on for her.

The number line was so popular I thought I would invite them to make their own number line. I provided long strips of paper and pencils beside the number line. This was as prolific as the writing had been when I made a notice board for the children in my first attempts as a 'meaningful literacy environment'. We published their number lines beside the feely one.

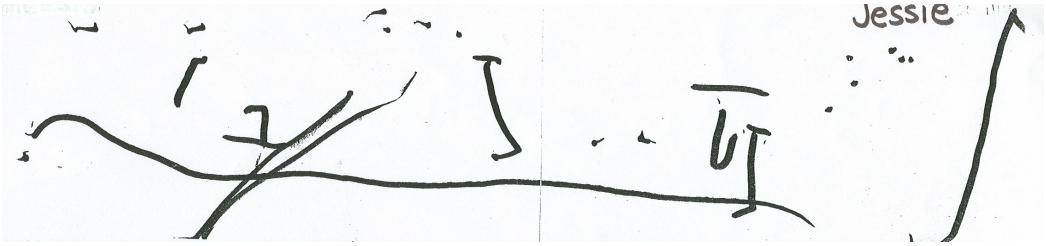

Figure 2 – Jessie

As can be seen, these examples could be considered examples of emergent writing. The children demonstrate their knowledge about numbers. Jessie (4 years old) is centering on her 'J'. This is the most important letter to her at the moment and she uses it for number symbols as well as writing symbols. Ashton-Warner (1965), in her teaching of reading, said that letters in a child's name are personal to them.

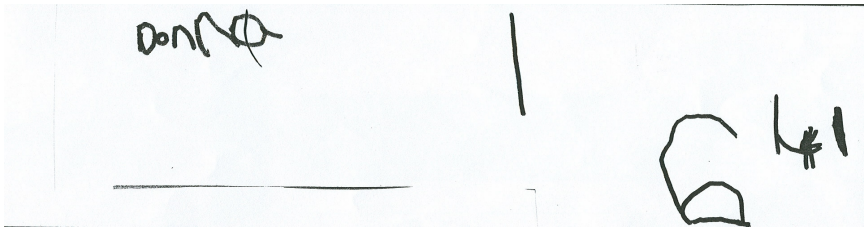

Figure 3 – Donna

Daniel (4 years old) is mixing up letters and numbers and taking a lot of risks. In observations of children's writing it has also been noted that this two-way use of symbols happened (Clay, 1975).

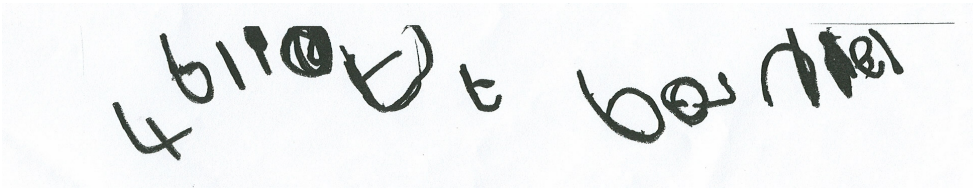

Figure 4 – Daniel

Donna (3 years old) the oldest one has 'one' fixed very much at the beginning of her line.

In all these examples the children 'moved' from left to right. They also showed how much they knew about written symbols.

In the number line area the connection between numeracy and literacy is clear. In literacy the claim was that if you make tasks more open then you find out more about the children. This was also evident in the number line area. By making the questions open I was finding out more about their idea of number: personal numbers were more meaningful to the children and where the children start from.

Looking at the number line again one could interpret this as children at different stages of number development. Three children only felt the numbers but made no responses. This may have been because it did not stimulate them to say anything or they did not want to or they did not yet recognise written numbers. A large percentage of the children talked about 'their' number as in their age number, this seemed to be a central focus to them just as letters of

their names. Children usually write the letters of their name first (and are motivated to do so) then use their knowledge of letters when writing other words. Their age number, a highly motivating factor and personal to them, hold the same power and it may be a number that they use in other contexts. For example, Daniel aged 4 years used the number 4 to put on a birthday card for his mum. What better number to give your mum than your own personal number!

Some children talked about favourite numbers (this may have been in terms of feel or colour). This favourite number talk stimulated conversation and some children named more than one favourite number thus giving indications that they about more than one number.

Touching and counting was the focus for some children. Perhaps this was a natural response. They may have thought that this is what you do with numbers, you repeat them in some kind of sequence, the sequence does not seem to alter. The number line provided the familiar sequence and they responded to it. Other children's knowledge extended beyond the counting. They were confident i8n their familiarity with numbers and were concerned about the sequence not having a number one. Two of the children knew that there were more numbers than 'one to ten' and wanted to continue the line not only beyond 10 but indeed before1. It could be argued that the children involved in the circus game mentioned earlier knew numbers had a function and could use them to create their own meanings.
These children who interacted with the number line were seen to have varied levels of number knowledge and involvement, some just wanting to look and touch but not expressing, at this time, any further response. Other children demonstrated quite developed comprehension of number enough to make self-initiated responses, indicating to the surrounding adults that they were building firm conceptual knowledge about the relation of numbers on a number line.

A positive model
It is interesting to note that because of the 'open' approach the children were able to tell us what they knew rather that what they did not know – for example, Guy who wanted to add to the space after 8 said we needed 10 and 12. Did he just think that only 10 and 12 came after 8 or did he know that 9 and 11 were numbers in that sequence? In the deficit model an educator might say that he could not count accurately after 8. However, in the positive model of observing learning t6hat was used in the study I saw guy as having knowledge of numbers beyond 8 and that he is able to articulate his knowledge. He seems to know that in sequence numbers 10 and 12 come after 8 rather than before. One could say that he has visual mental recall of those numbers (10 and 12) and that they came close to 8.

If looking at children's learning from a negative view (i.e. this is what she/he cannot do) it is unlikely that one can see the partial knowledge, or the emergence of a concept, or the gradual refining of approximations. From the developmentalist view, as I put forward in the study, it is vital to know this kind of information to facilitate and support the learning, whether it be more of a structured group input or providing opportunities in the classroom environment.

Co-operative learning and joining the mathematics club
In Amy's game children were observed supporting Amy and each other in the naming of numbers. It could be said that the children were learning about numbers through the number game – the naming, the order and ways to use numbers. Amy was also accepted in the game (and she had a high status because she initiated the game and was the 'leader') even although her skills of naming numbers were not quite as advanced as others in her group. She was learning from other children (they were also learning from her, for example, in organisational skills). Acceptance for Amy meant she was in a relaxed atmosphere with no pressure for right or wrong answers. I believe this encouraged her learning.

Smith (1988) referred to children becoming proficient readers and writers only when they joined the 'literacy club'. They become accepted members of this community of writers and readers. In the same way the children in the number line were a community of mathematicians giving each other support. Their use and knowledge of mathematics was growing within a social context.

Number readiness
In the light of the ever increasing research (Young-Loveridege, 1987; Womack, 1993) we seem to be moving towards the premise that the way for children to learn about numbers is exposure to numbers. Exposure to numbers in the environment does not actually mean didactic teaching, as children make their own meanings from their experiences. This is especially true if the children are empowered to guide the learning, and receive appropriate teacher responses at relevant times. Children are always 'ready' fro number.

Pre-number
In the literacy movement the notion of pre-writing was discarded along with the idea of reading-readiness. Children were observed as readers and writers from the beginning before they came to school. Language learning was not a linear series of steps. Coltheart (1979) demonstrated that reading readiness has no basis. It could be argued that the notion of pre-number has no foundations either. The Durham Project, cited in Davis and Pettit (1994), stated that pre-number activities such as sorting and matching have little relevance to the acquisition of number concepts in young children. Further evidence supporting this can be found in another part of this study (Carruthers, 1997) which focused on a child from 18 months to 36 months. Sovay (the child in the study) was first noted to talk numbers at 22 months. However it would seem logical to suppose that she was already acquiring knowledge of numbers before she could talk numbers. If we have to go back further and further the pre-number idea becomes unhelpful, that is if we work from the same premise as developmental literacy and believe that children acquire knowledge about a subject long before they demonstrate acceptable conventions of that subject. The number line informed the teacher of what the children knew, showing they were able to interact with it and use it in their own way.

Conclusion
Human sense or child sense?
When the responses from the number lines were examined there was evidence that children were as keen to have a go at writing about and being interested in numbers as they were in writing words and letters. The adults around them were accepting and encouraging and the children freely experimented with their ideas.

The number line activity provided a perfect vehicle for observing children's own knowledge of number. The development of number ideas in the children studied was seen to be closely paralleled to the dev elopement of reading and writing. As a result of these findings several traditional views about number learning were questioned. Hughes (1986) and Gelman and Gallistel (1986) also studied children's personal number knowledge but in a structured clinical situation. The Hughes's study did make a kind of 'human sense' to the children and did provide us with some extremely useful insights on children and number. However, it was not immediately purposeful or natural to the children. Did they even have a choice? I feel now we have to jump from the idea of 'human sense' to observing children's learning in terms of 'child sense'. By allowing children to lead gives a deeper indication of their natural development, indicating ways to support their growing knowledge.

A spiral model of learning
A more traditional view of mathematical learning may see it as a linear model in which the child moves yup0 step by step. The children in the study displayed a wide range of number knowledge. They had partial understanding which they used successfully. They did not seem to be learning numbers in a hierachi8cal way. An alternative view therefore may be that mathematical learning is recursive, moving like a spiral coming back round, going forward in a sweep around and looking at the whole instead of small steps. It is this kind of model that Meek (1991) puts forward for literacy learning. Ernest (1991) proposes that this is exactly the way mathematical learning should be. Moyles (1989) suggests that play learning also takes a spiral form.

> Rather like a pebble in a pond, the ripples from the exploratory free play through directed play and back to enhanced and enriched free play, allowing a spiral of learning spreading ever outwards into wider experiences for the children and upwards into the accretion of knowledge and skills, (Moyles, 1989, p.15).

Desirable Outcomes
The recent SCAAA Document (1996) 'Desirable Outcomes for Children's Learning' puts forward that children on entering compulsory schooling should 'recognise and use numbers to 10 and are familiar with larger numbers from their everyday lives, (p.3).

On the one hand, one could say, this document supports the development of children's number knowledge, especially with recognition to larger numbers within a social context. However, the outcome has not been backed with any rationale or theoretical underpinning. The complexity of young children's number knowledge needs sensitive and appropriate teaching. One cannot presume this will happen by giving a desirable outcome. Indeed there is a danger ahead if we expect unqualified early years workers to take on these complexities. Simple statements lead to simple teaching.

It has been implied in this article that young children's acquisition of number knowledge is similar to the developmental literacy model of learning. There have been recent writings about this parallel between literacy and mathematics (see Atkinson, 1992; Whitebread, 1995; Carruthers & Worthington 1996) but, as yet, there has been little significant research into this developmental theory and young children's learning. It would seem that further research into this link is vital to give us a better insight into the teaching and learning of number in young children.

Note
At the time of the study the author was teaching in the nursery department of Walter Daw First School, Exeter. I would like to thank the nursery nurses, Tracie Weeks and Jenny Love at the Walter Daw First School in Exeter, for helping with this study.

Refrences:

Ashton-Warner, S (1965) *Teacher.* New York: Simon & Schuster.

Atkinson, S. (1992) *Mathematics with Reason.* London: Hodder & Stoughton.

Briars, D.J. & Seigler, R.S. (1984) 'A feature analysis of pre-schoolers' counting knowledge.' *Developmental Psychology,* 20, 607 – 18

Cambourne, B. (1988) *The Whole Story.* Sydney, Australia: Aston-Scholastic.

Carruthers, E. (1997) 'The Pattern of Children's Number – a Developmental theory'. Unpublished dissertation, University of Plymouth

Carruthers, E. & Worthington, M. (1996) 'Emergent Mathematics: linking research and theory' *Primary Practice.* 5. p14-17.

Clay, M. (1979) *What did I write?* London: Heinemann Educational Books.

Coltheart, M. (1979) 'When can children learn to read – and when can they be taught?' in T.G. Waller & G. E. Mackinnon.

Davis, A. & Petit, D. (1994) *Developing Understanding in Primary Mathematics.* London: Falmer.

Gardner, I. (1996) 'Mathematics Rules,' *Strategies.* Vol. 6. No. 4. p.26-29.

Ernest, P. (1991) *The Philosophy of Mathematics Education.* London: Falmer.

Frydman, O. & Bryant, P.E. (1988) 'Sharing and understanding of children's number equivalence by young children'. *Cognitive Development.* 3. p323-39.

Fuson, K.C. (1988) *Children's Counting and Concepts of N umber.* Neew York: Springes-Verlag.

Gelman, R. & Gallistel, C.R. (1978) (reprinted 1986) *The Child's Understanding of Number'.* Cambridge, Mass: Havard Univesity Press.

Holdaway, D. (1979) *The Foundations of Literacy.* Leamington: Scholastic.

Hughes, M. (1986) *Children and Number.* Oxford: Blackwell.

Meek, M. (1991) *On Being Literate.* London: The Bodley Head.

Moyles, J.R. (1989) *Just Playing? The Role and Status of Play in Early Childhood Education.* Milton Keynes: Open University Press.

Piaget, J. (1965) *The Child's Conception of Number.* New York: Norton.

Rose, S. & Blank, M. (1974) 'The potency of context in childrrne's cognition: an illustration through conservation. *Child Development.* 45. p.499-502.

SCAA. School Curriculum and Assessment Authority, (1996) *Nursery Education, Desirable Outcomes for Children's Learning.* London: DfEE. HMSO.

Ofsted, Office for Standards in Education, (1996) *A Guide for Inspectors*. London. HMI.

Schrupram, A.M. & van Luit, E.H. (1995) 'Young children's counting strategies, an observational study.' *European Early Childhood Education Research Journal.* Vol.4. No.1.

Smith, F. (1998) *Joining the Literacyu Club: Further Essays into Education.* Porstmouth, N.H. Heinemann.

van Oers, B. (1996) 'Are you sure? Stimulating mathematical thinking during young children's play.' *European Early Childhood Education Research Journal. Vol 4. No.1.*

Wells, G. (1987) *The Meaning Makers.* London: Hodder & Stoughton.

Whitebread, D. (1995) 'Emergent Mathematics' in J. Anghileri. (ed) *Children's Mathematical Thinking in the Early Years.* Cambridge: Cassell.

Womack, D. (1993) 'Game, set and match'.TES. 8th October, (1993)

Young-Loveridge, J.M. (1987) 'Learning Mathematics'. *British Journal of Educational Psychology.* 5. p155-67.