Primary school mathematics – to what extent is symbolic representation a key factor in the development of recording skills?

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Abstract

Despite research having been undertaken over a number of years on the teaching of Mathematics in Primary schools (see Reynolds & Muijs, 1999 for a review) this issue remains problematic as noted in the recent DCSF (2008) report.

“After significant early increases, improvements in attainment in primary mathematics have slowed in recent years. Pupils reaching the expected standard at Key Stage 2 (age 11) rose from 59 to 72 per cent between 1998 and 2000 (Figure 2). Since 2000 the trend has, however, levelled off, with continuing small increases in most years at Key Stage 2. At Key Stage 1 (age 7) the proportion of pupils reaching the expected standard has remained at around 90 per cent. In 2007 nearly a quarter of pupils did not reach the expected standard before entering secondary school. Some six per cent (34,000) of these 11-year-olds had only acquired mathematical skills at or below those expected of a seven-year-old” DCSF (2008)

Indications from the data suggest that those who do well in Foundation Stage assessments are those who will achieve well in later years, agreeing with the assumptions made by writers such as Wright, Martland and Stafford (2000) and David (2003). However, interrogation from school data reveals that those who do well in mathematics assessment due to their ability to write numbers also do well in creative development and those who are not able to use formal notation do not achieve as well in creative development. Focusing on two groups of children the comparison suggests this may be due to the ability of the child to use symbolic representation in play situations.

Key research questions were, therefore:

- Does early recognition and recording of numbers indicate high achievement in later school years?
- How do children record numbers in Early Years settings and how is this supported by adults?
- Is the ability to understand symbolic representation a key factor in the development of recording skills?
Findings from this research will, therefore, provide useful insights into the link between symbolic representation and the recording skills.

**Introduction**

The purpose of this research was to investigate whether the ability to understand symbolic representation was a key factor in the development of recording skills and whether the ability to record numbers is an indicator of later high achievement in mathematics. The hypothesis was that if these factors are interlinked then it may be possible to accelerate learning in mathematics by focusing on symbolic representation through play activities. Given that school and County data suggest that early achievement in mathematics is an indicator of future high achievement then focus on this in the Early Years may have an impact on achievement later on. However, it is acknowledged that the evidence is not sufficient to conclude that there is correlation between these two figures, but a general assumption can be made that County and School figures indicate that this is so. Although this is not an indicator for all children suggesting that what happens in the subsequent schools years has a bearing on performance or for some children the assessment process may not be an accurate indicator of ability.

When children enter into the Foundation Stage they move from the informal meaning of mathematics learned in their home environment into the formal school mathematics curriculum where the emphasis is on abstract symbolism (Carruthers & Worthington 2006) they also enter an environment where, through play, they are encouraged to expand their mathematical understanding and are assessed by criteria laid down in the Foundation Stage Profile (DfES 2003) on Problem Solving, Reasoning and Number. During this time their development is also assessed using a nine point non sequential scale on Communications Language and Literacy, Knowledge and Understanding of the World, Creative Development, Personal, Social and Emotional Development and Physical Development. Although the assessment is non-sequential, children cannot achieve point 9 unless they have achieved all the early learning goals in that particular area of development, and the scale is ordered in approximate levels of difficulty (DCSF 2010). The purpose of this assessment is to inform the teaching staff of a child’s ability when making the transition from the Foundation Stage to Key Stage 1.

**Background**

The school selected for this research evidenced average point scores at the end of Key Stage 1 for Mathematics. Whilst this was above the national average figures have, since 2004, declined from 18.4 to 17.3. (Raiseonline 2007) This mirrors the National picture which shows that the Average Point Score for Mathematics at the end of Key Stage 1 over the past five years attainment has dropped slightly from 16.3 in 2003 and 2004, 16.0 in 2005, 15.8 in 2006 and 15.8 in 2007. The achievement in the Foundation Stage for mathematics in the target school is, however, in line with National average although the percentage of learners achieving 6+ points is above average in all areas other than for Numbers and Creative Development. This finding led the researcher to question whether there may be a link between the ability of children being able to record numbers and their ability in creative development. For
children to achieve 9 points (working beyond the early learning goals) in number, assessment must reveal that the child recognises, counts, orders, writes and uses numbers up to 20, to achieve at the same level for creative development a child must “Responds to own work and that of others when exploring and communicating ideas, feelings and preferences through art, music, dance, role play and imaginative play” (QCA 2008:82)

The target school is located in a rural area with 107 on role. The percentage of children eligible for free school meals in 2007 was 5.6% (national average 13%), there were no pupils with a statement of SEN, attendance was high with no unauthorised absence and the school deprivation indicator was 0.1. 86% of the pupils were from the catchment area, in which 29.1% of household area were categorised as high social class. The school had single year classes and intake in one form entry in September. The curriculum in the Foundation Stage was based on child directed play as promoted by the Curriculum Guidance for the Foundation Stage (DfES/QCA 2000), and the reviewed Foundation Stage Curriculum introduced in September 2008. The importance of this pedagogy is explored by writers such as Cohen (2006) and David (1999). The parents/carers of the children attended on a regular basis; this is also the philosophy of Early Years settings encouraging the involvement of parents/carers. It is widely accepted that parental involvement is crucial at this stage in a child’s education as they have had a significant impact on their previous learning and achievements (Tassoni and Hucker 2000). It is this prior experience that David (1999:57) suggests is not appreciated by schools, and as such they fail to build on the prior learning that has taken place. This view is supported by writers such as Carruthers and Worthington (2006). They go on to discuss the language used in the home and how this is often in conflict with the language used by teachers. This suggests that the transition from home to school environment for some children may be confusing and a time for adjustment to contrasting ideas.

The school uses the Local Authority Calculation Policy, this Policy states that ‘From Foundation Stage upwards children would never be expected to record anything that did not make mathematical sense to them’ L.A. (Bedfordshire CC 2007:online p16). In the research school, there is a daily activity planned to encourage mathematical awareness, and during the second half of the spring term whole group sessions of 10 minutes duration were introduced everyday to teach mathematical principles through teacher led activities.

**Methodology**

The methodology adopted for this research was qualitative and data was gathered through interview, observation and journal entries of play activities focused on two distinct groups of children - those who were not recording numbers at the beginning of the summer term, (Group B), and those that were able to record numbers in the previous September when they commenced school, (Group A).

Children in Group A all displayed an ability to use symbolic representation in their play, that is using objects to stand for something else such as a stick as a broom, sword or magic wand. Group B did not, for instance when riding a bicycle that is
what the vehicle was, a bicycle. For children who use symbolic representation the
bicycle could become a spaceship, home, magic carpet or double-decker bus.
Because Group A were able to use an alternative object to stand for something else in
play, they were revealing their ability to represent the world in a symbolic way (Smidt
2007). As formal notation, writing numbers, is a symbolic representation of a set,
moving from the concrete to the abstract, then this may suggest a link between the
ability to use symbolism and recording skills.

Nemirovsky and Monk (2000) conclude that if children can gain an understanding in
their play that one thing can represent another then the symbol and meaning are ‘fused
in the children’s experience’ (2000:178). In order to test out this theory a focus
group was set up to show the children in Group B how to play using symbolism with
one another in play situations. This was achieved through modelling by an adult who
participated in the role play sessions. These sessions took place four times a week for
a period lasting initially for 15 mins determined by the interest of the children, as the
research progressed the time spent in this small group varied from 10 – 45 mins. This
adult-led, focussed play did lead to positive results in the way these children
developed their interactions with others. For example, one child who very rarely
spoke to others in the Unit responded verbally to both the adult and the children
during these group activities. Another child who normally displayed aggressive
behaviour towards others played co-operatively when in this small group.

Research Groups

All the children in the Foundation Stage commenced school in the September prior to
the research which was undertaken during the following Spring/Summer terms.
Following observation and interrogation of class information two groups of children
were selected for inclusion in the research. Group A comprised of nine children who
had commenced school the previous September, they assessment data collected by the
staff of the setting revealed that all these children were able to record their numbers to
10 on entry to school. Group B (four children) included all the children in the
Foundation who were unable to record numbers when commencing school and still
were unable to use formal notation, these children formed the focus group for adult-
led activities. Before assessment of their mathematical ability took place background
data on each child was examined to see if there were common significant
characteristics linking these children within the two groups. This data included
gender, month of birth, place in family, attendance at pre-school and predominant
writing hand. No connection was found.

At the commencement of the research children in both groups were assessed to
ascertain their mathematical awareness. These assessments were carried out on all the
children and involved asking the children to:

- write their numbers 1 - 10
- recognition of regular patterned dice
- recognise irregular pattered dice
- count objects placed in a line
- recite numbers 1 – 10 forward and back
interview asking set questions on writing numbers

This assessment was used to give the researcher an indication of their ability to record numbers, sequence, and recognition of symbolism and number conservation.

Comparison of these results indicates that all children in Group A were able to record their numbers to 10 and beyond, although some numbers were reversed, and able to draw circles to represent a number in a set. Child (2004) questions whether this indicates understanding, however, observations in taught sessions indicated that these children did understand. These observations were carried out by the researcher watching the mathematics sessions led by the class teacher. Group B were unable to write recognisable numbers although keen to use the pencils to make marks on the paper, showing no division between writing and drawing (Worthington 2007). This indicates that they were beginning to use their own symbols for numbers. They could, when the digit was read out to them, draw circles for numbers although their accuracy declined the greater the number, and they had to go back and recount, Group A completed the tasks successfully. Unlike Group A, Group B children were unable to recite numbers counting back.

The recognition of the dots on dice gave an indication of their ability to recognise a symbol for a number. Group A children recognised the regular patterned dotted dice without the need to count the dots, Group B children all counted the dots and also used this strategy for the dice without the conventional pattern. Group A with the unconventional pattern took several seconds to recognise the number of dots. When asked ‘are you sure’ they all looked back at the dice, this is in contrast to the reaction when asked the same question to the familiar pattern when they did not need to refer back to the dice. Group A also showed an understanding of conservation of number whereas children in Group B were unable to consistently show their understanding of conservation. From this initial assessment it would appear that all the children in Group B had patchy mathematical awareness, however this was contradicted in several of the observations. During one activity a member of Group B showed an ability to double numbers to 6 whilst playing a dice game, however this ability was not displayed in another activity. Therefore although assessments give an indication of the mathematical awareness these cannot be used in isolation, as it would appear that in different circumstances and different situations some children are able to achieve at a higher level (Bentham, 2002). However, if from these observations we can conclude that success is dependent on factors other than the ability to demonstrate set assessment criteria, such as previous experience of engaging with a game, the richness of play opportunities supported by a more experienced other, interest of child, activity with no set rules as suggested by Carruthers and Worthington (2006) and Cooke (2000) then assessments may not be an accurate reflection of ability.

At the beginning of the research Group A children were interviewed to discover their views on how they learned how to write numbers. The purpose of these interviews was to see if there were any similarities between their recollections. Most children said that they had learnt how to record numbers at home. They said that their mummy had taught them or made reference to watching a popular television programme had been the reason for learning how to write numbers. This would suggest that those children who are given opportunities for this at home before they start school may
have an advantage. It is this prior experience that David (1999) state is not built on in school.

Observations

All children were observed in a variety of different play situations, interestingly those in Group A often played together and comprised what appeared to be two friendship groups. These children happily interacted in play situations; they readily improvised when resources were not available and used one thing to stand for another. This was clearly evident in an observation where four of the children were observed acting out a pirate role-play. They had swords (cupboard tubes) tucked into their belts made from strips of fabric which they also used as telescopes, had made a variety of head coverings using fabric, card or paper and then discovered they needed treasure maps. They went to the mark making table and rolled up pieces of paper, asking an adult to tie these with string. These rolls of paper were used to represent maps, although no child attempted to write on these or in fact unroll them in play, just referred to them as maps. They then returned to the rectangle of blocks laid on the floor to represent their boat. Without adult intervention they happily played together. This is in contrast to the observations of Group B who were not seen using symbolic representation in play. The group did not play together in any identifiable group but tended to play alongside other children in parallel play. For example during one observation a child from Group B was observed watching another small group playing with blocks making a roadway for their cars. The child, after a few minutes watching, joined the group by picking up a block and standing watching the other children. One child looked at him and smiled then told him to put the block in a line. The child from Group B responded by placing his block on the carpet away from the group and crouched down to play with the block without joining the others but frequently watching what they were doing. In other observations Group B were often observed playing on the peripheries, watching the other children play. Whilst appearing comfortable in their play activities they did not appear to be fully engaged often watching and listening to others. At no time during the observations did any member of this group approach an adult to engage in conversation other than to request help or permission to do something. Members of Group A were observed engaging adults in conversation to ask “what are you doing” or to find out further information “when are you going to” type questions.

Observation also took place at table top activities. In the Foundation stage there was always an activity planned to encourage mathematical awareness frequently supported by an adult. Group B only visited this activity when requested to do so by an adult, they complied with the requests of the adult to play a game or complete a task, moving away when it was indicated by the adult that they could do so or sometimes remaining in the seat watching the activities of others. This was in direct contrast to Group A, they were observed engaging with the task with and without adult presence. Dryden, Forbes, Mukherji & Pound (2007) believe that adult presence is the key to instructive practice, however these observations appear to suggest Group A were able to make the decision themselves as to whether an adult was needed in order for them to engage and/or perhaps an interesting activity to engage in. All observations of this type of activity revealed that children engaged according to the intentions of the adult. When engaging with the mark marking activity again Group B were enticed to join and often appeared happy to remain at the table even after completion of a task.
whereas Group A used the table to supplement their games rather than use it as a discrete activity. For instance, as with the example given earlier they would make props to support other play activities.

The conclusion from comparing the observations indict that the two groups approach play in different ways, interact at two different levels and whereas Group A are happy to improvise and use symbolic representation, Group B did not appear to engage with this type of play although were seen to watch whilst others engaged in these activities.

**Adult-Led Play Activities**

As a result of the findings from the assessment and observations adult-led play activities where the adult initially set up a play opportunity and allowed the direction of the play to be determined by the children, were set up over a period of six weeks to encourage the development of symbolic play in Group B. These were opportunities for the children to join a group activity to explore the use of symbolic play. These activities took place four days in each week, the duration was determined by the interest of the children therefore some sessions were relatively short and lasted only for a few minutes whilst other activities lasted in excess of 1 hour. The positive findings from this intervention indicated that children can be taught how to play using symbolic representation, one thing standing for another, as a result this may impact on their ability to use symbolism in other ways. For example, during the first week the children needed a great deal of support to use objects to stand for something else. The first play activity was to play in a pirate ship, following a class theme, in the hall using a variety of junk material. This involved a great deal of input from the adult to encourage the children to take part. Using the prior experience from the classroom activities the adult encourage the children to use cardboard rolls as telescopes, card as swords and fabric for different props. As the week progressed the children were able to contribute more and more building on their experiences of playing with the adult and other children. As the weeks progressed the adult slowly withdrew her input and the children begun to suggest different ways of using objects, and their involvement in the activity become more spontaneous rather than following instructions.

**Conclusion**

The literature suggests that achievement in mathematics may be linked to different factors in three main areas. The first theory being those who are able to record numbers in the early years may have an advantage over the lower achievers in subsequent years and that this gap may not diminish over time. It would appear that some writers are suggesting that the theory ‘once ahead always ahead’ applies to this group of children (Wright et al 2000). The second main argument is that it is the way children are taught, the pedagogy in the early year’s educational system, which will determine the child’s outcome. The child who has access to an instructional environment rich with positive adult interaction may be advantaged, and Siraj-Blatchford, Muttock, Gilden & Bell are of the opinion that it is within these settings that children progress well (2004). However, as all the children in this research were taught in the same setting then the results appear to contradict this theory as they all had equal access to the same environment. It is an interesting point that the children in group A, when playing together used speech to represent things, actions and ideas, the children in Group B did not. As a result in free play Group A reinforce their skill at this kind of representation but Group B do not. Therefore, the research implies that
it is not only a rich environment that contributes to the progress but other factors. The third theory that unless children understand symbolic representation they will not be able to record numbers, this being a symbolic process (Carruthers and Worthington 2006) and formal notation reflecting understanding of mathematics appears to be the case for Group B. In contrast Children in Group A all displayed an ability to use symbolic representation in their play, Group B did not. This indicates that symbolic representation may be a key factor in the development of recording skills. Group A are able to use an alternative object to stand for something else in play, they are revealing their ability to represent the world in a symbolic way (Smidt 2007). As formal notation is a symbolic representation of a set, moving from the concrete to the abstract, then the research would support the view that Group A are able to use symbolism and have developed recording skills. In addition to these theories, the work of Medwell and Wray (2007) in their writing research about writing letters, suggest that when children write letters reliably and automatically this then frees up their working memory. In their research they suggest that as the working memory is comparatively limited in size, when tasks become automatic the working memory is freed up for other aspects of composition. The debate around this research may have implications for the progress of children in mathematics.

The above suggests that if we concentrate on the child’s ability to use symbolic representation that this may be the key to accelerating learning in formal notation. Through the focus group activities it was possible to show the children in Group B how to play using symbolism and how to interact and collaborate with one another in play situations. This adult led focused play did lead to positive results in the way these children developed their interactions with others, began to use formal notation and learned how to use symbolic representation in their role play. Previous experience is a prerequisite for abstract learning, and if these children in Group B do not possess this information then it will be very hard for them to understand symbolism (Smidt 2007 and Child 2004). Therefore by offering them experiences to gain this knowledge, by creating an environment which encourages symbolic play, the adult intervention facilitates the taking up of an offer by the child, an experience that may not have been present previously, this may result in moving their learning on and in this case supporting both creative and mathematical development. The positive results from the research support the view that children can be taught symbolism by giving them the opportunity to attain these previous experiences. It is this concept that Nemirovsky and Monk conclude is vital, if children understand in their play that one thing can represent another then the symbol and meaning are ‘fused in the children’s experience’ (2000:178). The findings of this small scale research give an insight into the possible link between being able to write numbers and symbolic play.
References


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