Tracking nursery children's counting

Leanne Gray

The University of Birmingham

This study explores how a child's competence in counting develops during the Nursery year in a state-funded primary school in central London where all of the children speak English as an additional language. For this doctoral research project I tracked the developmental journey of seven children in the Nursery setting. I carried out task-based interviews with the children over the year and evaluated their counting skills and their ability to spot counting mistakes made by a puppet when counting in a real-life context. I also observed the children counting in class and reviewed their class teacher's planning and assessment of counting to triangulate the data gathered in the task-based interviews. I interviewed the parents of the children involved at the beginning of the study to establish relevant contextual information.

Keywords: nursery; counting; EAL

Introduction

Children's mathematical knowledge on entry to school is significant because there is increasing evidence that this knowledge indicates subsequent success in mathematics later on in schooling (Aunola, Leskinen, Lerkkanen, & Nurmi, 2004; Aubrey, Godfrey & Dahl, 2006). Research shows that there are great individual variations in the mathematical knowledge of children by the age of four (Fuson, 1988; Aubrey, 1993). This indicates that children's preschool and home experiences are impacting on their levels at the start of school and parents play a key role in this preschool experience.

As counting is one of the first mathematical skills that children acquire and forms a foundation for other mathematical activities (Briars and Siegler, 1984), I tracked the development in counting made by seven children during their Nursery year to explore any common themes or trajectories for the children.

Through my review of the literature I identified a gap in the current research regarding the development of competence in counting for children with English as an additional language. I also identified a gap in current research into how individual children's competence in counting develops over time. This has led to my research question being:

> *How does a child's competence in counting develop during the Nursery year in a primary school where all children speak English as an additional language?*

The research context

The study took place in a state-funded primary school in central London. Nearly all children in the school arrived in Nursery working at levels considerably below the age-related expectations (Early Education, 2012) and the children in this study all

reflect this. All pupils in the school are defined as speaking English as an Additional Language (EAL) because they have a different first language to the language spoken in school. Vygotsky (1986) stated that the language we use and hear controls and structures our thoughts. Therefore, language is important in constructing mathematical knowledge and is particularly significant in helping to understand the counting development of children in this research context. In this study levels of English were assessed using the 'Language and Understanding' framework of the EYFS Development Matters document (Early Education, 2012).

Research framework

I used the five counting principles identified by Gelman and Gallistel (1978) as a framework for my research. The first three principles define the counting procedure. These three principles are the stable order principle, the one-to-one principle, and the cardinal principle. The stable order principle states that the tags are applied in a consistent order over each count. The one-to-one principle states that each item is tagged with only one distinct counting word and that each counting word is only applied to one item. The cardinal principle states that the number word allocated to the final object counted represents the number of items. The fourth principle is the abstraction principle and determines the types of sets that can be counted. This principle states that the first three principles can be applied to both tangible and intangible objects. The fifth principle is the order-irrelevance principle that states that it does not matter what order the items are counted.

Gelman and Gallistel (1978) reported that there is a developmental relationship between the principles. Children learn a stable-order of number words before they learn the one-to-one principle. These two principles are then followed by the cardinal principle. However, researchers have identified that one of limitations in the testing procedure used by Gelman and Gallistel (1978) was in their identification of the order of the development of the principles (Frye, Braisby, Lowe, Maroudas & Nicholls, 1989) and have since found that this developmental relationship only applies to very small sets of objects (Fuson, 1988).

A child can demonstrate procedural competence in counting by being able to perform a task, such as successfully determining that there are five items in an array. However, children may learn these procedures in mathematics, by observing and copying others count, without meaning and therefore may not be able to generalise their knowledge to other situations (Hiebert and LeFevre, 1986). Judging when a child has achieved competence in counting is challenging because counting is made up of many different concepts (Sophian, 1997). Researchers have determined children's conceptual understanding of counting through assessing their judgements about the validity of another's counting (Briars and Siegler, 1984; Frye et al., 1989). This is because it has been shown that children are better able to recognise counting errors when others count than in their own counting (Gelman and Meck, 1983; Fuson, 1988). Also, when identifying mistakes made by others children need only monitor adherence to the counting principles rather than applying each of the counting principles (Gelman and Meck, 1983).

Therefore, researchers have asked children to identify mistakes in others' counting. These researchers included unusual counts that still achieved the correct answer in order to assess whether children could identify which counting rules were necessary. It has been argued that because children were able to identify mistakes in

others' counts and identify when an unusual count still achieved the correct answer they showed conceptual competence (Gelman and Meck, 1983).

Methods

To address the research question I used four methods of data collection. The first method was ten task-based interviews with each child over the academic year. The design of the task-based interviews drew on the interviews used by Briars and Siegler (1984). These interviews were used to evaluate children's counting skills and their ability to spot counting mistakes made by a puppet when counting. My interviews differed from those used by Briars and Siegler (1984) because I set the interview in a real-life and familiar context linked to the children's learning in class. This is because it has been shown that children can be more successful at solving mathematical problems if they are set in meaningful contexts rather than in abstract contexts (Donaldson, 1978).

The second method of data collection was observation of the children during whole class counting sessions. These observations were carried out six times over the academic year. The third method of data collection was reviewing the class teacher's planning and assessment of counting. The data collected in the task-based interviews was triangulated with the data gathered in the observations and reviews of planning. The final method of data collection was an interview with each of the parents of the children involved at the beginning of the study to establish relevant contextual information.

I analysed the task-based interview data by recording the outcomes into matrices. The matrices were organised into columns according to current literature about stages of development of counting and divided into the ten different interviews so that the learning trajectory could be clearly seen. The outcomes were then colour coded green, orange or red. Green indicated a correct count, orange indicated a partially correct answer and red indicated an incorrect answer or no attempt to answer the question. On the matrices I recorded the language used by the child and any observations about their gestures. The class observations and the teacher's planning were also recorded onto matrices so that I could look at what was happening in the classroom at the time of each task-based interview. After initial analysis using the matrices I was then able to identify key themes and patterns and explore them in more detail.

Findings and discussion

All of the children in the study showed significant developments in their counting between the beginning and end of the Nursery year. My initial analysis of the data revealed that there was not a 'typical' trajectory in the development in counting for the children in the study. However, the analysis revealed that the children fit into three distinct trajectories of development. These three groups also reflected the children's level on entry to Nursery in 'Number' and their levels of English. All three groups were below age-related expectations according the assessment framework used by the school (Early Education, 2012). The first group were 'significantly below', the second group were 'below' and the final group were 'just below'. Rather than explain each individual child's trajectory, I have focused this explanation of the developments in counting on one child in the study from the 'below' group, Maryam, but have indicated how other children in the study were similar or different in their trajectory of development in counting. I used the principles of counting to structure my

questions in the task-based interview so have used these principles to structure my findings.

To find out about the development of understanding of the stable order principle children were asked "how high can you count?". If children did not appear to understand the question I would begin to model the counting sequence. In terms of the stable order principle Maryam, like all of the other children in the study, showed a significant improvement between the first and final task-based interviews. In November she recited the counting sequence to five and this progressed to counting to the twenties by July. However, Maryam, like all of the other children, showed some inconsistency in the highest number she could count to, with this number going up and down at each task-based interview. Also, teacher observations of Maryam in the classroom indicated that she could count higher than she demonstrated in the task-based interview. This may have been for a number of reasons; Maryam may have felt more comfortable and relaxed in the classroom environment than in the task-based interview. It is also possible that she had heard another pupil count in the classroom and was repeating what she had heard. In the task-based interviews, when she reached numbers in the twenties Maryam often confused the sequence, for example "23, 24, 29, 26". Two other children from the 'below' group in the study also did this. This could be because the teacher's planning indicated a focus on counting up to 20. Maryam, like other children in the study from each of the three groups, also demonstrated some difficulty when crossing the tens boundary at either the number 10 or the number 20. Although this could be for a number of reasons it does suggest that children memorise the number words up to 29, despite the patterns (Munn, 1997). Also, the teacher's planning indicated a focus on counting up to 10 at the beginning of the school year or 20 towards the end of the school year.

In terms of the one-to-one principle, Maryam's progress did not follow a consistent trajectory over the year; this is similar to all other children in the study. In the first task-based interview, in October, when asked the question 'how many conkers are there?', Maryam recited number names at random and picked up the objects on the table. There was no correspondence between saying the number word and picking up the object. However, from November to January Maryam correctly answered the 'how many' question, counting from left to right and touching each of the four objects. This matches with the teaching of counting delivered during this first term in Nursery during which the staff focused on modelling how to count up to five objects by touching each object. The next three months demonstrated some inconsistencies in Maryam's understanding of the one-to-one principle. For example, in February, Maryam touched one object multiple times. In April she made a skim error, reciting the number sequence but not specifically pointing to objects as she counted, skimming her finger along the row of objects. There did seem to be some progress in the gestures used by Maryam to support her in counting. In each task-based interview until January she touched the objects as she counted, but this progressed to just pointing at the objects in March whilst still counting accurately. When asked to judge the accuracy of a puppet's application of the one-to-one principle, Maryam first spotted that the puppet had missed out an object in March; this was four months after she had demonstrated that she could accurately count a set of objects. Maryam, like all but one child in the study who was in the 'below' group, did not identify the double count mistake made by the puppet.

Maryam's progress in the cardinality principle depended on the question asked. When asked the question "how many conkers are there?" Maryam showed progress, albeit inconsistent progress, over the year. However, when asked 'can you

give me four conkers' from a larger set of six conkers Maryam counted out the objects accurately but did not stop at the requested number. There was a similar pattern for all of the other children in the study, with no children being able to correctly answer the 'give me' question, even though they could confidently and accurately answer the 'how many' question. This suggests that children are able to respond more accurately to 'how many' questions rather than to 'give me x' questions (Frye et al., 1989, Wynn, 1990). 'Give me x' tasks are believed to be more challenging because the child has to create the required set of objects one object at a time, until they have created the value that corresponds to the one in their memory (Cordes and Gelman, 2005). It is therefore proposed that this question provides a more accurate assessment of the cardinal principle than the 'how many' question.

With regards to the abstraction principle, children were asked to count a set of jumps made by the puppet and to give the puppet four claps to say well done. Maryam was accurately able to count each jump made by the puppet, but when the puppet stopped jumping she continued counting. All other children, at various points in the year, were also able to count each jump made by the puppet. This suggests that all of the children understood that they could count things that are not concrete objects. However, like Maryam, none of the children stopped counting when the puppet stopped jumping. This again supports the finding that they did not yet understand the cardinality principle. All of the children were able to count the jumps made by the puppet before they could clap and count the number of claps. This could be because the clapping task required them to think about moving their own body at the same time as counting. Both children in the 'significantly below' group did not manage to clap the counts at any of the task-based interviews. Again, as with the jumping question, all of the children counted the claps past the requested number of claps. This again suggests that they did not understand cardinality.

In January, Maryam was very insistent that the puppet had made a mistake with his counting when he started counting in the middle, and when he counted alternate items in a row. She had begun to spot that the puppet was not following the usual conventions of counting by not counting from left to right. However, Maryam was not yet showing an understanding of the order-irrelevance principle because she did not accept that the puppet had counted correctly because he had started counting in the middle. The same occurred in at least one task-based interview for all but the two children in the 'just below' group.

Conclusion

Although there were limitations in that this was a small scale study of only seven children in one primary school there were nevertheless some interesting findings. There is no suggestion that the findings of this study are generalisable to a larger population of bilingual learners. The findings of this study are generated from a very specific group.

This study has revealed that, for the children studied, there was not a 'typical' trajectory of development of counting skills. However, there did seem to be a more consistent path of development for children who started in Nursery at similar levels in 'Number' and 'Communication, Language and Literacy'. All of the children studied showed inconsistencies in their path of development, for example, they appeared to be secure at counting four objects in response to a 'how many' question over several task-based interviews but then would not be able to answer this question correctly in a subsequent interview. The study also suggests that procedural understanding of

counting develops before conceptual understanding. With regards to the cardinal principle the findings suggest that this is not fully understood by any of the children at the end point of the study because none of the children were able to respond accurately to the 'give me' question.

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