The Significance of Counting

Effie Maclellan (1993) University of Strathclyde

What does it mean to say that someone can count? For the adult, counting is a seemingly straightforward activity: the adult notices the set of items to be counted, assigns a number name to each item in the set and recognises that the last number name used defines the total number of items in the set. That adults are skilled in counting is not surprising. They have practised the skill for many years: in fact most have been practising this skill since the age of two (Gelman and Gallistel[1])!

This may well be something of a surprising revelation to the reader. However, it is not being claimed that two year olds can count with the same level of skill and sophistication as adults. But what is being stated is that the rudiments of counting can be observed in many two year olds.

In recent years a considerable amount of research has been done to investigate the emergence of children's counting. This research has highlighted that counting is both a very complex process and a very important process. What this means, both in terms of what young children do and in terms of what adults might do to help them, will now be explored through a consideration of some questions which the reader might have in mind.

Question

How long does it take for the child to learn the number names?

Answer

How long is a piece of string? With exposure to the number names most children will normally have learned the sequence up to 100 by about six or seven years of age (Fuson and Hall[2]). Typically, two to three year olds can reliably produce the string 'one, two, three', though after 'three' may well become confused. The hardest part of learning the number names is learning the sequence from 'one' to 'thirteen'. This is because all the names are so very different from each other. By the time the child has learned the number name sequence to 'twenty', he/she may have spotted part of the repeating one to nine pattern: four and fourteen, six and sixteen, seven and seventeen and so on. By the time the child has learned the number name sequence to 'thirty', he/she will have a firmer grasp of the repeating one to nine pattern: four, fourteen and twenty four, six, sixteen and twenty six and so on. It seems that no one actually teaches children about the repeating one to nine pattern but that they work it out for themselves. Once children have mastered the number name sequence to twenty and have grasped the repeating one to nine pattern, all that is left for them to learn are the decade names: thirty, forty, fifty, sixty and so on, though here again some children may discern for themselves the pattern in the decade names. And so it would be perfectly logical for the child to refer to one hundred as tenty.

To summarise then, it takes most young children four or five years to learn the number name sequence up to one hundred. While this in itself is a huge undertaking it appears that children really only have to learn the number names up to twenty or thirty. With this knowledge, it seems that in large measure, they work out that all number names from twenty onwards are derivations from a very small stock of names.

<u>Question</u>

Can children be said to count when they know the number names?

<u>Answer</u>

The answer here is a categorical "No". Counting involves much, much more than the rehearsal of strings of number names. Paradoxically, however, children may well be able to count in a very real sense and yet make mistakes in their use of the sequence of number names. Many children initially develop their own idiosyncratic sequence of number names such as 'one', two', 'five', 'six'. If the child repeatedly and consistently applies this one list to counting arrays of up to four objects and repeatedly defines three objects as 'five' and four objects as 'six', this child could be said to be counting. The sequence of number names as conventionally used has actually no greater validity than any idiosyncratic sequence which is used consistently. The only reason that we learn the conventional sequence is to aid and enable communication.

<u>Question</u>

So what <u>is</u> meant by counting?

<u>Answer</u>

Counting involves three procedures, which were hastily referred to in the very first paragraph of the text.

(1) In counting an array of items there has to be a pairing of each item with a number name. The person making the count has to mentally 'move' (and possibly physically move) each item from a to-be-counted category to an already-counted category and, whilst doing this, has to assign a different number name to each item. This pairing procedure is open to different types of error. One type of error is when the person making the count either counts an item twice or fails to take account of all the items. Another type of error is when the person making the count makes a mistake in using the number names (perhaps using the same number name twice). A third type of error is when the person making the count fails to 'move' and name the items in a synchronised fashion: for example the number naming may be in advance of the 'moving' of items; the naming may continue after the 'moving' is complete; or during the procedure there may be a failure to maintain one-to-one correspondence such that although the procedure begins and ends in synchrony there has been some confusion in between.

(2) A second procedure involved in counting has been alluded to earlier. While assigning a number name once, and only once, to each item in the array is important, it is not enough. Additionally, the sequence of number names generated must be reliably produced from one count to another. Thus the person who consistently counted four items as 'one', 'two', 'butter'. 'four' could be said to be counting whilst the person who used a variety of sequences such as 'one', 'two', three', 'four' on one count but 'one', 'four', 'three', 'two' on another and 'one', 'two', 'six', 'nine' on yet another could not be said to be counting.

(3) The third procedure involved in counting is the recognition (and demonstration of that recognition) that the final number name used has a special significance. Unlike any of the preceding number names used, this final number name defines the total number of items which were counted. This third procedure, technically referred to as the application of the cardinal principle or the application of cardinality, is later in developing than the first two procedures but is also dependent upon the first two procedures. So the child may well be able to pair number names and items-to-be-counted and may assign the number names in a fixed order but may not further know that the last number name assigned represents the numerosity of the set of items. The child can said to have developed the cardinal principle when, on being asked how many items there are in the set, either of the following behaviours are evidenced:

(i) the child counts the number of items in the set and repeats the last number name: as in one, two three; three!

(ii) the child counts the number of items in the set and on arriving at the last one gives its number name additional vocal stress: as in one, two **three**.

On the other hand, the child who on being asked the 'how many' question either does not respond or (sometimes repeatedly) goes back to the beginning and executes the first of the two procedures (as outlined above), can be said not to have developed a knowledge of the cardinal principle.

So, in summary, counting involves:

(i) a pairing of number names and items such that each item is named once and once only;

(ii) the use of a list of naming words which is produced in a fixed sequence;

(iii) defining the total numbers of items in a set by the final number name used in the sequence.

Question

But I had always been taught that before children can really learn to count, they must be able to sort objects into groups?

Answer

Yes, this view has become fairly entrenched amongst many who teach young children. The view stems from people like Piaget[3], Bruner et al[4], Klahr and Wallace[5] and Ginsburg[6] who identified that young children classify together objects which look like each other but only much later use the abstract notion of number for the purposes of classifying objects. From these observations, a faulty line of reasoning developed. It was argued that because children first classify objects on the basis of perceptual similarity, they couldn't count collections of objects which were visibly different from each other. However just because children did not count sets of visibly different objects does not mean that they could not count them. Indeed there is evidence (Maclellan[7]) that children **will** count collections in which the items are very different. Children will count elephants, bananas and toys or girls and lollipops or houses and balls and refer to such collections as "things".

So what does this mean for the importance of 'sorting' activities, so firmly established in early education? It probably means that there is no harm in such activities and they may indeed be useful for some educational purposes. However, in terms of their value in assisting the formation of number concepts generally and, in promoting counting particularly, the 'sorting' activities could be dispensed with.

Question

So if 'sorting' activities are not essential to counting, what about 'matching' activities? Don't children need to have one-to-one correspondence before they can count?

Answer

The simple answer is, "Yes, children do need to have one-to-one correspondence in order to count" but what is questionable is whether children need to engage in the 'matching' activities of assigning straws to cups of juice, eggs to egg cups and hats to heads. If the child can pair a number name with an item and continue pairing a different number name to each new item in the set, the child already has one-to-one correspondence. What sometimes gets forgotten is that one-to-one correspondence is an abstract notion. It is not something which we can see. It is something which we infer from observing two types of behaviour. One type of behaviour, as already mentioned, is counting. The other type of behaviour, commonly referred to as 'matching' is technically known as correspondence construction (Klein and Starkey[8]). Correspondence construction is the pairing or mapping of every item in a set with, or onto, one and only one item in a second set, for the purpose of judging equivalence. Both correspondence construction and counting begin to emerge in children as young as two years. While both types of behaviour depend upon the abstract knowledge of one-to-one correspondence, it is not the case that in order to count, the child must be able to physically construct a correspondence.

Here again the significance of 'matching' activities in early education may need to be revised. It is conceivable that 'matching' activities could have some educational value but the contribution such activities make to the child's progress in counting is probably minimal.

Question

Is counting important?

Answer

The importance of counting is increasingly being understood by more and more people. Counting is a pre-requisite for many other mathematical activities. For example being able to read the time on an analogue clock requires one to be able to 'count on'; being able to count every nth number in a series is useful for summing coins, for telling the time, for multiplying. What is of greater significance to the teacher of young children, however, is that counting is the means by which young children penetrate the concepts of addition and subtraction. When a set of items has been transformed either through some items being added or removed, the only strategy which the young child has for defining the outcome of the transformation, is counting. The implication of this is that if counting is such a powerful mental tool then many children will be able to add and subtract before they begin formal schooling. The research evidence (Carpenter and Moser[9], Gelman and Gallistel[1], Hughes[10]) indeed supports very clearly the notion that three and four year olds have informal knowledge about addition and subtraction.

Finally it might be worth pointing out that counting is important because it is through many repeated experiences of counting that the child learns that number names are temporary and arbitrary designations only and that it matters not what order the items are counted in (so long as they are all counted and counted only once). For adults this knowledge is both commonplace and highly abstract. As adults we might find it difficult to remember when we first realised that the order in which items are counted is irrelevant. But because physical objects do not themselves have the property of number, it is not possible to point to a 'three' or a 'two'. Yes of course it's possible to point to the word 'three' or the numeral 'three' or to a set of 'three' things. But is not possible to point to an example of a 'three'. For this reason then, number is a totally abstract concept. The construction of the concept of number is no small achievement for adults. So for young children, still very inexperienced in the world, grappling with the abstract concept of number is an enormous achievement. Counting is the earliest way in which the child can begin to construct the concept of number.

Question

What can I do to promote the young child's learning with respect to counting?

Answer

Much in the same way as good readers are those people who do a lot of reading, young children who are good at counting have had lots of practice. Gelman and Gallistel[1] point out that many children can be observed counting when there is nothing in the immediate environment which demands it. In other words many children will count, for the sake of the intrinsic satisfaction which they derive from the activity of counting. Clearly then counting practice can be valuable and enjoyable. Frank[11] makes the following suggestions to assist the teacher.

1. For those children who may not have developed the conventional list of number words, there is nothing to be lost and indeed much could be gained by some rote counting: the rehearsal of the number names in sequence, say, perhaps, to ten.

2. The pairing of a number name with an item can be better managed by children if they point to each item in the set. Pointing while saying the number names is a cue to the child that each item is counted once and only once.

3. Be ready to model for the children the observable behaviour you wish them to demonstrate. If you want the children to touch the items as they are being counted, show them clearly what you want. Check and correct, with further demonstration, those who are having problems in synchronising the touching and the naming. Similarly, be ready to make explicit what children seem to know, but do not articulate clearly. For example, having executed a count correctly, the children can be told/reminded that the last number name used in the count tells how many are in the set.

Together with overt practice in counting, it is also now recognised (Hughes[10], Van Devender[12], Fuson[13]) that in using their fingers for counting, children can make sense of counting more easily. Traditionally in formal education settings, there has been a fear that children would become over dependent and possibly handicapped by reliance on fingers for counting. This in turn led to various degrees of prohibition by teachers on the use of fingers. At the moment there is no evidence that by using their fingers to support their counting, children are handicapping themselves either in the immediate or longer term.

In summary then, teachers can best help young children through activities which are directly concerned with the rehearsal of number names and with counting. Teachers, further, should encourage children to use their fingers.

References

1. Gelman, R. and Gallistel, C R. (1978) The Child's Understanding of Number, Harvard University Press: London.

2. Fuson, K. and Hall, J. W. (1983) 'The Acquisition of Early Number Word Meanings: A Conceptual Analysis and Review' in H. P. Ginsburg (ed) The Development of Mathematical Thinking, Academic Press: London.

3. Piaget, J. (1952) The Child's Conception of Number, Routledge and Kegan Paul: London.

4. Bruner, J., Olver, R. and Greenfield, P. (1966) Studies in Cognitive Growth, John Wiley and Sons: London.

5. Klahr, D. and Wallace, V. (1973) 'The Role of Quantification Operators in the Development of Conservation' Cognitive Psychology, 4, 301-27.

6. Ginsburg, H. (1977) Children's Arithmetic, D. Van Nostrand Company: New York.

7. Maclellan, E. (1990) Teaching Addition and Subtraction by the Method of Bi-directional Translation, unpublished Ph.D. thesis.

8. Klein, A. and Starkey, P. (1987) 'The Origins and Development of Numerical Cognition' in J. Sloboda and D. Rogers (eds) Cognitive Processes in Mathematics, Clarendon Press: Oxford.

9. Carpenter, T. and Moser, J. (1982) 'The Development of Addition and Subtraction Problem-Solving Skills' in T. Carpenter, J. Moser and T. Romberg (eds) Addition and Subtraction, Lawrence Erlbaum: New Jersey.

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

11. Frank, A. (1989) 'Counting Skills', Arithmetic Teacher, 37, 14-17.

12. Van Devender, E. (1986) 'Fingers are good for early learning' Journal of Instructional Psychology, 13, 4, 182-7.

13. Fuson, K. (1992) 'Korean Children's Single-Digit Addition and Subtraction', Journal for Research in Mathematics Education, 23, 2, 148-65.