The importance of counting in early number development

Counting is the action of finding the number of elements of a finite set of objects by continually increasing a counter by a unit for every element in the set, in some order. Counting is used by children to demonstrate knowledge of the number names and number system. Archaeological evidence suggests that humans have been counting for at least 50, 000 years, and in ancient cultures counting was used to keep track of early economic data. Learning to count is considered a very important educational and developmental milestone in most cultures of the world. Learning to count is a child's first step into mathematics, and constitutes the most fundamental idea of mathematics. The present essay will attempt to illustrate the importance of counting for the development of number-related skills from an early age (Eves, 1990).

The use of numbers is a skill developed from an early age. In mathematics, there is the term " number sense", a relatively new construct that refers to a well organized conceptual framework of number information that enables a person to understand numbers and numbers relationships, and to solve mathematical problems that are not bound by traditional algorithms. Number sense includes some component skills such as number meaning, number relationships, number magnitude, operations involving numbers and referents for numbers and quantities. These skills contribute to general intuitions about numbers and pave the way for more advanced skills (Bobis, 1996).

Studies have shown that this " number sense" begins at a very early age. Even before they are able to count properly, children of around two years of age can indentify one, two or three objects. Theorists as early as Piaget noticed this ability to instantaneously recognize the number of objects in a small group. Piaget called in “ subitizing”. Later, as the child’s mental powers develop, around the age of four, groups of up to four objects can be recognized without counting. Adults have and continue to use the same ability of subitizing, although even they cannot use it beyond a maximum of five objects, unless the objects are arranged in a particular way or practice that aids memorization. Subitizing refers to the mind’s ability to form stable mental images of patterns and then associate them with a fixed number. In a familiar arrangement, such as six dots arranged into two rows of three (such as in dice or playing cards) six can be instantly recognized when presented this way (Gelman & Gallistel, 1978).

Yet, with the exception of familiar arrangements such as the examples above, when people are presented with groups numbering more than five objects, they must resort to other mental strategies. Groups can be broken up into sub-groups to facilitate the process. A group of six objects, for example, can be broken up into two sub-groups of three, which are recognized instantly and then unconsciously combined into six, the number of the bigger group. This strategy does not use any actual counting, but a part-part-whole relationship which is assisted by rapid mental addition. Therefore, there is an understanding that a number can be composed of smaller parts, along with the knowledge of how these parts add up. This kind of thinking has already begun by the time children begin school, around six or seven years of age. It should be nurtured and allowed to develop, as it is thinking of this sort that lays the foundation for understanding operations and developing mental calculation strategies (Bobis, 1996).

Skills such as the ability to perceive subgroups, need to be developed alongside counting in order to provide a firm foundation for number sense. Although there is no denying that counting is crucial for the development of numbers, these other skills play an important part as well. Skills and alternative strategies for counting can be developed more effectively by the use of teaching strategies. Children can be shown flashcards with objects in different arrangements (sometimes six in a cluster of four and a pair, or sometimes in three pairs) as these different arrangements will tend to prompt different strategies. Furthermore, if the flashcards are shown for only a few seconds, the mind is challenged to act faster and develop strategies other than counting to make the necessary calculations (Way, 1996).

Yet, despite the importance of alternative strategies, a considerable amount of evidence supports the idea that counting is the most important mechanism used by young children in estimating numbers of all sizes, perhaps only with the exception of 1 or 2. Subitizing and grouping, as described above, are used as mediators for the ability to understand small numbers, but it seems that even these skills are developed after children have learned to estimate numbers by counting. Moreover, counting is the basic mechanism used when children learn to add and subtract. At least the initial stages of adding and subtracting, before the child masters the processes, involve counting. For example adding 8 and 3 might be achieved by first counting to 8 and then proceeding to 11 (Gelman & Gallistel, 1978).

A surge of interest in counting was triggered by Gelman and Gallistel’s (1978) book, which claimed that preschoolers’ learning to count was inexplicable unless they had innate predispositions to learn counting. So, is counting innate or not? Butterworth et al. (2005) believe that the human ability to count is innate and is not reliant on numbers or language to express it. They based their study on the fact that the children of Australian Aborigines were able to count even though their languages do not have words for numbers. An extreme form of linguistic determinism has been developed recently, which claims that counting words are needed for children to develop concepts of numbers above three. In contrast, the team's study of aboriginal children suggests that humans have an innate system for recognizing and representing numerosities, the number of objects in a set, and that the lack of a number vocabulary does not prevent them from doing numerical tasks that do not require number words.

On the other hand, other cross-cultural studies support the opposite conclusion: counting is not innate. Although it seems to come naturally, counting may be cultural rather than innate. Many hunter-gatherer societies such as the Australian Aborigines or various different peoples in South America have no words in their languages for counting or at best only words for up to the number five. This could be because those societies do not have the culturally supported contexts where exact numbers need to be encoded. To investigate the issue, one study (Hyde et al., in press) examined a population of deaf Nicaraguans who do not speak Spanish and never had the opportunity to learn conventional sign language. These people live in a numerate culture that uses exact counting and large numbers, but because they were never educated in it, they lacked conventional language for themselves. Still, these individuals did not spontaneously develop representations of numbers over three. They use gestures to communicate about numbers but do not consistently produce gestures that accurately represent the cardinal values of sets containing more than three items. This is in contrast to native speakers of the American Sign Language, who, raised and immersed in a language that uses counting, were just as good as speakers of Spanish and English at counting. Therefore, deafness was not the factor that made the difference.

The overall point, though, is that whether innate or not, there can be little doubt that counting is crucial for early number development. People belonging to those cultures without words for numbers larger than five can subitize up to a point but are handicapped when the need arises to deal with larger quantities (Butterworth et al., 2008). Activities that involve counting have been shown to to be very effective for helping young children understand the concept of number. Young children and prepared to engage in and benefit from preschool exposure to counting before they are taught arithmetic in an organized manner. Children form many necessary language associations at a very early age, and even at the early age of three, certain counting principles are already in place. Children can make effective use of guided experiences that help them build developmentally appropriate pre-formal mathematics understandings. Counting can be used to reinforce and extend children's natural learning. The highly influential book of Gelman and Gallistel (1978) proposes a set of counting principles, and counting exercises based on these principles contribute greatly to children's pre-formal understanding and progress toward formal understanding.

Gelman and Gallistel's principles do not refute Piaget's classic, ground-breaking findings on the processes of development, but rather extend them.

Some of these principles are attainable by age three and all of them by age five. Many counting exercises that emphasize these principles also employ the logical activities recommended by Piaget, such as classification, seriation, matching and comparison (Aubrey, 1993). The one-to-one principle shows that, when counting, only one number word in assigned to each object. This refers to both the verbal and mental act of counting. The stable order principle shows that, when counting, number words are always assigned in the same order. Although the tie of number to language is important, exercises that employ stable order are most useful when they simultaneously employ the previous, one-to-one principle. The cardinal principle shows that the number of objects in the set is the last number word counted. The cardinal principle is similar to the concept of cardinality, of which children gain implicit understanding long before they understand numerical quantity. The order irrelevance principle shows that when counting the number of objects in a set, the order in which they are counted is not important, but rather simply that all objects are counted. In other words, a set of objects may be properly counted by starting with any object and going in any order. Finally, the abstraction principle shows that when counting any unique set of objects, all the above principles apply as well as they do to any other unique set.

Researchers as early as Beckmann (1924) analyzed the way in which children arrived at an accurate estimate of the number of items, in order to establish the importance of counting. Depending on their behaviour during a counting task and their explanation of how they reached the answer, Bechmann divided the children into “ counters” or “ subitizers”. In general, it was found that the younger the child, the greater the tendency to count for all numbers, while the larger the number, the greater the tendency for all children to count. These results together showed that children estimate a number by counting before they can subitize the same number. Similar effects were observed by Brownwell (1928) and McLaughlin (1935). By asking children to identify the number of elements in arrays of 3 to 10 objects, Brownwell noticed that young children almost always counted and rarely took advantage of the patterns in the display. McLaughlin similarly observed that 3- to 6-year-olds typically counted in order to determine the number of objects in an array, even when the number of objects was small. As the number of items a child could count increased, so did the ability to estimate numbers.

Gelman (1972) notes that when the performance of children in experiments where they have counted is compared with that in experiments where they did not count, the resulting discrepancy adds support to the hypothesis that young children initially estimate by counting. Buckingham and MacLatchy's (1930) study on estimation showed children a random throw of objects, and the subjects were not prevented from counting. In contrast, in Douglas' (1925) study where three similar number tasks were used, children were discouraged from counting. If the groups of 6-year-olds in these and other studies that accordingly encourage or discourage counting are compared, a large discrepancy can be observed. In the first case, the percentage of children who accurately estimated non-linear arrays of around 10 items on at least one trial varied from 54% to 70%, while in the latter case only 8% of the children successfully estimated the numerosity of 10-element arrays.

Although the studies differed in a variety of ways, the similarity of the tasks, the selection of the same age group and the use or absence of counting suggest that at least some part of this impressively large discrepancy in successful estimation scores can be attributed to the presence of absence of counting.

Overall, the role of counting on early number development is not entirely clear and there are many different, often conflicting, opinions on how these processes occur. The most striking example is whether counting is innate or not, with some researchers claiming that humans are born with the ability to see the world numerically in the same way that they are born with the ability to see the world in colour, and others insisting that it is a cultural, not an innate ability which will not develop outside of a cultural setting that reinforces it. Different opinions also exist in the matter of the importance of counting and the importance of other skills such as subitizing. Subitizing and other similar skills that assist in estimations are crucial, but they only seem to be so when used together with counting. Counting develops first and produces much better results in estimates and numerical tasks in general. It is the first mechanism used in estimation, the most effective one, and also equally crucial when developing other, more complicated numerical skills such as adding and subtracting. It truly seems to be the basis of early number development.