CHAPTER 8

THE IMPACT OF METHOD ON ASSESSING YOUNG CHILDREN’S EVERYDAY MATHEMATICAL EXPERIENCES

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Many children arrive at school with an impressive understanding of mathematics. As Baroody, Lai, and Mix (2006) pointed out in a recent review of the literature on children’s development of a sense of number, “mathematical learning begins early, very early” (p. 196). Although there is still a good deal of debate at precisely when this learning starts (see, for example, Baroody, 2004; Mix, Huttenlocher, & Levine, 2002; Starkey, Spelke, & Gelman, 1990; Wynn, 1998), it is clear that by age 3 or 4 children have had a great deal of mathematical experiences (for reviews, see Baroody et al., 2006; Ginsburg, Cannon, Eisenband, & Pappas, 2006; Ginsburg, Klein, & Starkey, 1998). Ginsburg and his colleagues were thus led to state that we have “a rich understanding of the ways in which children construct an informal knowledge of mathematics in the everyday environment” (1998, pp. 401–402). However, as Hannula (2005) pointed out with regard to number, “nearly all our knowledge of young children’s number recognition skills is based on studies that explicitly direct children’s attention to the aspect of number” (p. 11). The same is true of the other areas of math-
ematics, with a relative dearth of research focusing on how much, and under what conditions, young children play with mathematical shapes, talk about time, estimate distance, and so on in the course of their typically occurring everyday activities. Our focus in this chapter will be on this type of informal mathematics that occurs during the course of preschool-aged children’s typically occurring everyday activities, rather than what can be seen in laboratory or other controlled conditions. As we will show, however, the methods used to assess children’s involvement in everyday mathematics heavily influence the apparent extent of their involvement.

SOME THEORETICAL PERSPECTIVES ON EVERYDAY MATHEMATICAL EXPERIENCES

There has for several centuries been a strand of ideas about education that have stressed the active role of the developing child coming to gain an early understanding of mathematics. Although these ideas are often portrayed as simply allowing children to develop in as natural a way as possible, the guiding role of adults is still very important. This position can be seen clearly in Rousseau’s writings, particularly *Emile* (1762/1969) which begins: “God makes all things good; man meddles with them and they become evil.... Yet things would be worse without this education... Under existing conditions a man left to himself from birth would be more of a monster than the rest” (p. 5). One can trace the development of these early ideas about educating children through the work of Pestalozzi, Froebel, Montessori, Dewey, and others, including the notion that it was possible to help young children to learn mathematics by having adults provide appropriate opportunities for them (Balfanz, 1999; Baroody et al., 2006; Nouriot, 2005).

Piaget on mathematics. There are two misconceptions about Piaget’s ideas that are relevant to this chapter. First, there is the widespread notion that Piaget viewed children as developing on their own, “little scientists” actively working alone on the physical and logico-mathematical world as a way of coming to understand it. Second, some authors (see, for example, Baroody & Wilkins, 1999; Hughes, 1986) have attributed to Piaget the view that children’s early experiences in counting are irrelevant to their understanding of number.

What seems clear, however, is that Piaget believed that too much attention was being paid to the teaching and formative role of adults by representatives of the contemporary dominant paradigm in psychology—behaviorism. He was not simply critical of behaviorists, however; Piaget (1935/1970) also felt that Froebel, Montessori, and Dewey encouraged adults to be too directive with young children, and was explicit about the
fact that the development of early mathematics cannot be explained simply by teaching.

It is a great mistake to suppose that a child acquires the notion of number and other mathematical concepts just from teaching. On the contrary, to a remarkable degree he develops them himself, independently and spontaneously. When adults try to impose mathematical concepts on a child prematurely, his learning is merely verbal; true understanding of them comes only with his mental growth. (Piaget, 1953, p. 74)

Notice, however, that Piaget did not say that teachers (or other adults) have no role to play in the acquisition of mathematical understanding, merely that it will be in vain if it is “imposed prematurely.” It is also worth noting that the apparently maturationist position that children’s understanding appears “only with mental growth” is belied by numerous other of Piaget’s books and articles. Elsewhere he stressed that the child’s maturation is only one of four interrelated factors that account for development. Maturation is important, but as children mature they increasingly have experiences with the physical and logico-mathematical world, and with the social world (which includes factors of “social transmission, the educative factor in the large sense” Piaget, 1962/1973, p. 28). The fourth, and most important, factor is that of equilibration, the drive to resolve cognitive conflict in an increasingly adaptive way, through successive accommodations that follow periods of assimilation.

What Piaget argued, in fact, was that teachers do indeed have an important role to play in helping children learn mathematics, but that this role should be changed from the provision of “lessons” to that of “someone who organizes situations that will give rise to curiosity and solution-seeking in the child” and who, when the child has problems, needs not “directly to correct him, but to suggest such counterexamples that the child’s new exploration will lead him to correct himself” (Piaget, 1973, pp. 85–86). Piaget (1970) devoted an entire book, Science of education and the psychology of the child, to this topic, including in it a chapter about how teachers need to be trained to teach in a way most likely to help children learn. Elsewhere he wrote about the need for teachers to provide materials likely to challenge children’s logico-mathematical thinking, allowing them to try to learn by discovery in groups as well as individually, and to respond to their questions rather than trying to teach them (Piaget, 1930/1976/1998).

Many scholars have criticized Piaget for underestimating preschool-aged children’s understanding of basic mathematical concepts (see, for example, Donaldson, 1978; Hughes, 1986). Baroody and Wilkins (1999) note the common assumption that “little or no mathematical learning occurs before children begin school” (p. 49) and attribute theoretical support for this assumption to both Piaget and Thorndike. Baroody et al.
(2006) make the same claim, namely that Piaget has influenced psychologists and teachers to take a highly pessimistic view of what children can do mathematically.

This is clearly a misrepresentation of Piaget’s position, which is built on the basis that it is precisely through children’s early experiences (with numbers, objects, shapes, space, time, etc.) that they develop conservation of number, length, volume, etc. Much of The child’s conception of number (Piaget, 1941/1952) and The child’s conception of space (Piaget & Inhelder, 1948/1967) is devoted to showing this gradual development. Piaget provides innumerable examples of young children who are able to count but who are not yet able to conserve. As Piaget argued: “At the point at which correspondence becomes quantifying, thereby giving rise to the beginnings of equivalence, counting aloud may, no doubt, hasten the process of evolution. Our only contention is that the process is not begun by numerals as such” (1941/1952, p. 64). In other words, counting may well be beneficial, but the ability to count, in and of itself, is no evidence of understanding.

Vygotsky on mathematics. Vygotsky’s cultural-historical theory has been used in some senses as a counterweight to ideas that have been linked, erroneously in our opinion, to Piaget. Nourot (2005), for example, writes that “Vygotsky (1967) adds to [Piaget’s] model the importance of the social context for children’s learning” (p. 22). However, our reading of Piaget is that such a contrast cannot be so clearly drawn. Nonetheless, it certainly is fair to say that whereas Piaget devoted most of his energy to exploring the ways in which children constructed their views of reality by acting on the physical and logico-mathematical world, Vygotsky was more interested in the connections between children’s development and the sociocultural world in which they lived. Although he did not write a great deal about the development of mathematical understanding he described, as he also did for thinking and speech, the relations between the natural and cultural lines of development.

Vygotsky (1931/1997), like Piaget (1941/1952), wrote about the distinction between a perception of number and its concept. He gave examples of young children being able to perceive, directly, the similarity and differences between small numbers (e.g., in a game of dominoes), and of a child who could count the number of fingers on her own hand but was unable to tell how many fingers were on someone else’s hand. He described this initial ability as children’s natural, or “primitive,” ability, and contrasted it with what occurs after children have gone to school, and learned the “cultural” (or schooled) approach to number. Although he described the stages that children go through in their ability to count (Vygotsky, 1929/1994), his argument was that the natural line does not simply develop into
the cultural line, but that there is a “chasm” between children’s perception of number and the use of cultural signs.

There is no straight line in the child’s development, [but] a discontinuity, a replacement of one function by another, a displacement and conflict of two systems. How can the child be carried through what is a dangerous point for him? . . . [I]n no case can we ignore all the features of primitive arithmetic of the preschool child. They are the point of support from which the leap must be made. But neither can we ignore the fact that the child must decisively give up this support. (Vygotsky, 1931/1997, pp. 225–226)

The culturally mediated systems developed over historical time within society thus come to play an enormous role in the subsequent development of children’s mathematical understanding.

In the United States, at least, Vygotsky’s ideas have been appropriated by those interested in the development of young children as related simply to his concept of the zone of proximal development, which is commonly treated as synonymous with scaffolding, or teachers’ need to provide assistance just above the children’s current level of understanding (see, e.g., Baroody et al., 2006; Berk & Winsler, 1995). As others (e.g., Sophian, 1995, 1999; Tudge & Scrimsher, 2003b) have made clear, however, Vygotsky’s cultural-historical theory necessarily ties activities, such as engaging in mathematics, to the historically derived cultural practices of a group. This position has been well illustrated with regard to the street and school mathematics of children in Brazil (e.g., Nunes, Schliemann, & Carraher, 1993; Saxe, 1991), the approach to counting developed by the Oksapmin of New Guinea (Saxe, 1982; Saxe & Esmonde, 2005), and the everyday mathematical practices of adults (e.g., Lave, 1988; Scribner, 1984).

From the perspective of both Piaget and Vygotsky, then, there is much to be gained from studying the ways in which children engage in mathematics in the course of their everyday lives in the years before they enter school. The remainder of this chapter will be devoted to discussion of the ways in which researchers have examined preschool-aged children’s everyday activities, with particular reference to mathematics, as a way of showing that the extent of children’s involvement in mathematics depends in large part on the methods.

**CHILDREN ENGAGING IN EVERYDAY MATHEMATICS**

What do we know about the everyday, or informal, mathematics in which children engage? As we will portray in the next sections of this paper, the answer to that question depends to a large extent on the methods used to collect data. Essentially, four types of methods are used. One involves col-
lecting data by asking parents to report on what their young children do during their regular day, and is related to the diary (or experience sampling) methods that have been used fairly widely with adolescents and adults (see, e.g., Bolger, Davis, & Rafaeli, 2003). The proponents of diary methods (e.g., Hofferth & Sandburg, 2001) argue that the data gained are both valid and reliable, citing research comparing the time parents report watching television with the time they actually spend on that activity. However, it is far easier to remember watching a certain number of TV programs (each of which lasts for a certain period of time) than to remember the time spent in activities that have no such obvious duration. Moreover, a good deal of mathematics might occur unobtrusively as part of another activity, such as a child counting silverware as it is being laid on the table, and thus not be considered by the parent.

The remaining three approaches move away from a reliance on parents to do the reporting, and researchers themselves observe (or listen to) what children actually do in the settings in which they spend their time or, more rarely, train childcare teachers to observe what occurs while children are with them. This approach clearly has advantages over the first method, in that the researcher does not have to rely on parents’ memories of what occurred, and can be more assured of observing children’s activities even when the parents are not present. However, although live observations may be a good way of assessing the extent to which children are focused on mathematics, they may be a less effective way to provide a detailed account of the nature and type of the mathematics that occurs. One proposed solution is to audiotape, either in conjunction with observations or without the presence of an observer. This method may be a better means to note all details of the mathematical dialog that occurs in the child’s presence, but is clearly limited in that it misses all mathematics that occurs nonverbally. The final method that we will discuss is videotaped recording of what children do. It is this approach that is most clearly able to capture the extent to which mathematics occurs frequently and regularly in young children’s lives.

Parental and Teacher Reports

One of the first large-scale reports of how young children spend their time was conducted by the University of Michigan Survey Research Center in 1975–1976 and 1981–1982 (Juster & Stafford, 1985). Although the main focus was not on young children, parents were asked to report on the use of time by children as young as three years of age (Timmer, Eccles, & O’Brien, 1985). Parents were asked to provide, by phone, an ordered account of all the activities in which their children were involved during
the previous 24 hours. The results suggested that, in their waking hours, three- to five-year-olds spent about three and a half hours a day in play during the weekday, about an hour longer at the weekends, a little over two hours in some type of formal childcare or preschool setting, almost two hours watching TV, and almost an hour and a half eating. These young children were said to spend about seven minutes looking at books or being read to, two minutes a day in other school-relevant activities (including mathematics), and were involved in some type of household work about 15 minutes a day. However, Timmer and his colleagues pointed out the limitations of using the same type of diary for children of all ages and adults. “If we want to know what young children do when they play, or what parents and children do when they are together, it might be better to tailor a diary to these activities, getting detailed reports of time the children spend with their parents or of a child’s activities during a typical play period” (Timmer et al., 1985, pp. 356–357).

Hofferth and Sandburg (2001) used part of the 1997 Panel Study of Income Dynamics to get very similar information, collected in the same way as had Timmer et al. (1985) on U.S. children from birth to 12 years of age by asking parents to report on the starting and ending times of children’s “primary activities” and any activity occurring simultaneously during the previous 24 hours (with data collected during one weekend day and once during the week). The main activities of the three- to five-year-olds in this nationally representative sample look fairly similar to those reported by Timmer and his colleagues. During their waking hours, the preschool-aged children spent, on average, about two and a half hours a day in play, almost two hours a day watching TV, almost one and a half hours eating, and a little over an hour being cared for. Eighty-one percent of these children were involved in some type of household work, for an hour a day, on average, although 20% of the children were never involved in any type of work. The children, on average, spent almost three hours of their time in some type of formal childcare arrangement (with half of the children going to preschool and 25% of them in a childcare center). The children, on average, spent about seven minutes a day in conversation and 12 minutes a day looking at books, but these were activities that between 40% and 50% of the children were reported as never doing. About five minutes a day, on average, were spent in other types of school-related activities (including mathematics), but more than 80% of the children were reported to never be involved in these types of activities.

The type of methods used in these two studies are almost certainly not the most appropriate to get a sense of how much children are involved in mathematics, focusing as they do on broad categories of activities in which children could be involved. More explicit attention on school-relevant activities was found in the time-budget approach used to assess the extent
to which English five- to six-year-olds were involved in school-related activities at home (Plewis, Mooney, & Creeser, 1990). Parents of more than 150 children from London were interviewed, by phone, three times over a six-week period and responded to questions about their child’s reading, writing, and mathematical activities during the previous day. The average (median) child was reported to have spent two and a half minutes a day reading to a parent, less than two minutes reading to him or herself, one and a half minutes being read to, 13 minutes a day looking at books, no minutes writing, and no minutes a day involved in any type of mathematical activity. Some children (but fewer than 50% of the sample) did engage in writing (and did so, on average, almost five minutes a day), and some (30%) were reported as having done some mathematical activity in the previous 24 hours, but only for about two minutes on average.

Saxe, Guberman, and Gearhart (1987) also found little evidence that children were much involved in mathematics. They recruited almost 80 mother-child dyads, evenly divided by social class and age of the child (two- and four-year-olds). All dyads were of European American background from a borough of New York City. The dyads were seen in the home and also brought to the laboratory, and the children engaged in a series of number assessment tasks, while the mothers were interviewed about their attitudes about their children’s preschool experiences and expectations for the future. Most relevant to this chapter, however, they also asked the mothers to respond both to a questionnaire and to an interview about the kinds of number-related activities in which their children engaged at home.

During the interview, the mothers were asked to describe each number activity and indicate how often the children engaged in them. The majority of the children were said to initiate some type of number activity (counting things, reading number books, and using numbers in play) at least three times a week, and most of the mothers reported that their children were involved in various other types of number play more than once a week. Children from middle-class homes were reported as engaging in play that was more complex than was the case for working-class children and, as might be expected, the same was true for the older than the younger children. Interestingly, even though these children were typically reported as doing something mathematical less than once a day, Rogoff (1987) commented on these findings by saying that they showed that the children were “heavily involved” at home in games and activities involving mathematics.

Blevins-Knabe and Musun-Miller (1996) conducted two studies in which they asked parents to estimate how often their kindergarten children had engaged in number-related activities and skills in the previous week. In both studies, one with mothers of 40 European American three- to five-
year-olds and the other with mothers and fathers of 49 European American and African American four- to six-year-olds, parents were interviewed by phone, and asked to respond to the extent to which their children had engaged with number either in activities by themselves or with a parent. In both studies, the researchers asked the parents to respond to a specific list of 33 activities, of which 20 involved parent-child interaction. The activities to which parents responded included such items as whether the child had used “more” in a sentence, sung a number song, and put objects in order from smallest to biggest. It is interesting to note, however, that the activities of counting objects, reciting a series of numbers, using the words one, two, or three, and using the words from four to ten were treated as four separate activities. The parents were also able to mention any other type of number-related activity in which their children had participated.

On average, mothers in the first study said that their children had engaged in each of the different activities between two to three times a week, although Blevins-Knabe and Musun-Miller (1996) pointed out that there was a good deal of variability across both items and children. The second study, in which both mothers and fathers were asked to report on their children’s engagement in mathematics, revealed an overall average (between two and three times a week) virtually identical to that of the first study, despite a greater diversity of parent gender, race/ethnicity. On the other hand, the children in the second study were older than those recruited for the first study. The results of these two studies reveal, in other words, that when parents are prompted for specific mathematical activities they seem far more likely to say that their children had engaged in them during the previous week than occurs in the relatively open-ended questioning that Saxe and his colleagues (1987) used to ask about children’s books and games involving number.

Mathematics, needless to say, does not occur simply in the home, and many children spend a good deal of their time in some type of childcare setting in the years before school. However, we have been only able to find a single study in which childcare educators were specifically asked to report on the extent to which the children engaged in mathematics, focusing specifically on number. Hannula, Mattinen, and Lehtinen (2005), as part of a quasi-experimental longitudinal study to determine whether three-year-old children could be helped to focus more on mathematics, asked teachers from seven different preschools in Turku, Finland, to mark on a specially-designed chart whenever a child spontaneously counted or used numbers in some other way. Although one child of the 34 who participated was noted to focus on number 59 times one week and 65 times the second week, the remaining children focused between zero and 15 times during the two-week period of the study. The average was approximately four times during the first week and a little over five times during the second
week. Using a chart prompted the teachers for certain types of mathematical activity, but they were not explicitly asked (unlike in the Blevins-Knabe and Musun-Miller 1996 study) about the extent to which the children engaged in different mathematical activities. Nonetheless, there seems little indication that Finnish children are greatly involved, spontaneously at least, in mathematics in preschool.

In summary, then, it seems clear that when parents (or, occasionally, teachers) are asked to report on children’s engagement, informally, in mathematics the results obtained depend, to a certain extent, on whether or not parents are prompted for specific types of mathematical activity. Without such prompting, they are likely to say that children are involved very infrequently in mathematics (once or twice a day) but with such prompting up to 30 different types of mathematical activities several times a week. One interpretation is that prompting reminds parents of a specific type of mathematical activity (they might not otherwise have thought of their child asking for “more milk” as constituting a number-related activity); however, it might also be the case that social desirability might influence the extent to which they “remember” the child engaging in one or more of these activities.

However, parents and preschool teachers may not be the most suitable people to ask about how much their children are involved in mathematics. First, they have other things to do than simply observe their children. Second, their definition (explicit or implicit) of mathematics might be more restrictive (primarily dealing with number, for example) than that used by researchers, although this problem might be avoided by the type of close questioning used by Blevins-Knabe and Musun-Miller (1996). Third, parents, teachers, and the children themselves may not have mathematics as their primary focus during a particular activity but as subservient to their main focus (dividing a cake in order to eat it, building a tower that needs to be higher than the sofa, and so on), and so the parents or teachers do not think about the mathematics that is actually involved in the activity. In this case, it should be possible to see more evidence of mathematics when researchers themselves are doing the observations, rather than asking parents or teachers to report on the extent of children’s engagement in mathematics.

Observations of Naturally Occurring Mathematics at Home and at Preschool

One of the first researchers, at least in the United States, to examine the naturally occurring activities and interactions of preschool-aged children was Jean Carew (1980; Carew, Chan, & Halfar, 1976). As she pointed out,
she and her colleagues were “interested in the role played in their intellectual and social development by their normal, every day, encounters with people, places and things rather than in the effects of extraordinary traumatic events or special experiences contrived by social scientists” (1976, p. 5). They observed 24 children from the Boston area at home three to five times during each of four periods from 12 months until 33 months and a further 22 children were observed once a month at their childcare center, with these observations starting either at 18 or 24 months and continuing until the children reached 34 months (Carew, 1980). Both at home and in childcare the children were observed for a 40-minute period, 15 seconds for observation followed by 15 seconds during which the observer quietly recorded her observations into a tape recorder. In addition, the mothers were interviewed at home, and asked to describe the children’s activities during the previous 24 hours, although the majority of the discussion of children’s experiences is based on the observations.

Carew and her colleagues (1976) provided many vignettes from the lives of eight of the children, and several of them (all taken from when the children were 24 months) are clear examples of mathematical experiences: Sam filling up different sized jars and pouring them carefully from one to the other; Matthew building various towers with four different-sized blocks and then playing a game with his mother involving the naming (and mis-naming) of squares and circles; Sonja’s mother pointing to the number “4” and counting the objects in the picture and then measuring the tower that Sonja has just built against her own size; and Vicky’s mother telling her, while trying to dress her, that she needs to extend one foot and not two. Unfortunately, Carew et al. did not provide any indication of the extent to which mathematical experiences occurred. Carew (1980) went slightly further, noting that “intellectual experiences” (including mathematics) were seen in about 19% of the observations in the home and about 27% of the observations in childcare. These figures, clearly, are far higher than those reported by parents in the use-of-time studies described above.

Munn and Schaffer’s (1993) research in 10 nursery schools in Scotland, with two- and three-year-olds from deprived backgrounds, provided a more effective examination of the extent to which the children were involved in mathematics as they observed all activities of six children per school for 40 minutes each, noting all literacy and numeracy “events” that the children were engaged in, regardless of whether they involved language. “Numeracy” was defined as enumeration, classification, seriation, comparison, or one-to-one correspondence. Events were coded during 20-second intervals for five minutes in each of four different contexts (story time, during an adult-led activity, free play, and at mealtime) on two different days. Munn and Schaffer found that such events were far more likely to occur when the children were in the company of an adult than with peers, that numeracy
events occurred far less frequently than did those involving literacy, and that numeracy was more likely to occur during the course of literacy (e.g., during the reading of a story such as the *Three Little Pigs*) than alone. Both literacy and numeracy events occurred more frequently during story time and during the adult-led activities than during free play or mealtime. Across all contexts, however, an activity involving numeracy occurred in only 10% of the intervals (7% involving literacy as well and 3% simply as numeracy), whereas literacy occurred in more than 30% of the intervals. Munn and Schaffer noted that despite the abundance of materials relevant to numeracy and/or literacy, “the relatively low proportion of literacy/numeracy intervals without any adult interaction demonstrated the dependence on adults of such young children for literacy and numeracy experiences” (p. 71).

Tudge and Doucet (2004) also gathered observational data on children’s everyday mathematics, as part of a larger cross-cultural and longitudinal study (the Cultural Ecology of Young Children, or CEYC project) designed to describe children’s participation in all types of everyday activities (Tudge et al., in press; Tudge, et al., 2000; Tudge et al., 2003a). Like Tizard and Hughes, they gathered their data using the same methods in any of the settings in which children spent their time. Their intent, unlike that of Tizard and Hughes, however, was to describe the full range of activities that occurred across the equivalent of a full day in the lives of the children. Tudge and Doucet described the mathematical activities in which 39 three-year-olds engaged, based on 18 hours of observation of each child. Observations occurred in blocks of two and four hours over six days, with one observation period starting prior to the child waking, another occurring in the hours prior to bedtime, and the other blocks filling up the remaining parts of the day. Observations described what occurred during a 30-second period every six minutes, with the remaining time devoted to coding and writing field notes, leading to approximately 180 observations on each child. The children were evenly divided by race/ethnicity (20 of the children were from European American homes, and the remainder from African American homes) and each group consisted of equal numbers of middle-class and working-class families. Engagement in some type of mathematics was coded as a “lesson” (trying to teach the child something mathematical or a child asking for information, such as “let’s count together how many rabbits are in this picture” or “what is this shape called?”) or in the course of children’s play, when they were observed playing with objects that were designed with mathematics in mind (playing the card game “Uno,” putting together a puzzle based on geometric shapes, or counting for the fun of it [i.e., not as part of any apparent curriculum]).

The results revealed that these children appeared to be very little involved in mathematics; on average the children were involved in less
than one lesson and approximately one example of playing with objects that were designed to help children with mathematics. Too much weight should not be placed on these averages, however, as there was a good deal of variability. Between 40% and 70% of the children in each group were never observed in a math lesson, between 20% and 40% of each group only involved in one or two such lessons, whereas about 10% of each group were involved in three or more lessons. The same was true in the case of playing with math-relevant objects; between 45% and 80% of the children in each group were never observed in such play, between 10% and 45% of the children were observed just once or twice, although in all groups except the black middle-class children, approximately 10% of the children were observed in math play three or more times.

These very low numbers for engagement in mathematics are somewhat misleading. Although observers gathered data over 18 hours, the time-sampling method used means that data were in fact only gathered for a total of 90 minutes. For children to be observed, on average, having a math lesson once every 90 minutes, with data sampled over a full-waking day, translates to a little over nine lessons a day, assuming that children are awake for 14 hours. Given an average of one lesson and one time playing with some math-related object per 90 minutes, this would translate to children being involved with mathematics 18 times a day, on average. However, as Tudge and Doucet (2004) pointed out, their observational methods were such that the children were only coded as engaging in mathematics when this was their focus of attention. Arranging four sets of silverware on the table may well have helped the children with counting, conservation, classification, and so on, but if their focus was simply on helping a parent they would have been coded as engaging in work; the children would only have been coded as also engaging in mathematics if they had been counting, or showing in some way their focus on mathematics.

In sum, then, we can say that whether from studies involving parental reports or live observation in the home or preschool setting, children do not seem heavily involved in mathematics, which leaves open to question how it is that by the time they arrive in school many of them have developed rather sophisticated mathematical understandings. One possibility is that these methods are simply not sensitive enough to see the extent of young children’s mathematical experiences, particularly those that are not occurring deliberately and that are not the focus of the child’s attention. It also seems likely that observations in the home or childcare center, as is the case with parental reports, are not able to provide sufficient detail about the type and quality of mathematics that occurs in children’s lives. One approach that some scholars have adopted, as a way to get a more detailed examination of children’s mathematical experiences, is to audiotape children’s dialog, sometimes in conjunction with live observations.
Relying on Audiotape to Assess Young Children’s Engagement in Mathematics

Tizard and Hughes (1984) noted the widespread view that early experiences in the home are of critical importance to children’s development and, like Carew (1980), expressed surprise that virtually no research had been conducted to examine actually what went on in the home, apart from some intensive observations of very few children. (They also noted a study of children’s language development, by Wells, 1984, about which we will have more to say.) Tizard and Hughes declared that “the central interest of our study was to describe the educational contexts of the home” (p. 15). They therefore observed 30 English girls from London who were approaching their fourth birthday, half from middle-class and half from working-class homes, all of whom were attending the same nursery schools in the mornings and at home with their mothers in the afternoons. The children were fitted with a wireless microphone, and all the adult-child conversations were recorded during two afternoons at home and three mornings in the children’s schools.

Tizard and Hughes (1984) wrote a good deal about the obvious problems entailed in observing in the home, including changing behaviors because of the observer’s presence, difficulties of ensuring that the children would wear the microphone and transmitter, and the amount of work entailed transcribing and then analyzing the corpus of data that would be gathered, even though they decided not to use the data gathered on the first afternoon and the first morning. The opposing point of view was made by Blevins-Knabe and Musun-Miller (1996) who wrote as follows:

Studying the home environment presents immediate methodological problems. Naturalistic observation of behaviours in the home by an outside observer provides valuable information, but it may not present a complete or accurate picture due to reactivity on the part of family members and limitations on observer time. (p. 36)

Tizard and Hughes, however, made a strong case for the validity of their observational method (see also Hughes et al., 1979).

Tizard and Hughes (1984) noted that some children played card games with their mothers, which involved relatively sophisticated knowledge of number order, and had puzzles that required matching a number symbol with the correct number of objects. Others, apparently completely spontaneously, asked questions about simple addition or joined in as their mothers counted the number of objects in a shopping list. The authors noted:

The contexts of the home provided many natural settings for counting. The mothers counted knives as they set the table, counted the items on their
shopping list, asked the children to count the number of people coming to tea, or the number of sausages they had put on each plate. The children obviously enjoyed counting and often initiated it themselves. (p. 94)

Nonetheless, the *Learning at home* about which Tizard and Hughes wrote seemed to involve relatively little mathematics, certainly by comparison with the extent of conversation about the children’s play, about controlling the children, the children asking questions or asking for something, and so on. The mathematics that does arise, for the most part, does so embedded in conversations with a very different focus—one child being told that she can have “one more drink of rosehip” so that she does not drink “the whole bottle” (1984, pp. 104–105); another child talking about putting her toys into her toy pushchair and her mother telling her “I don’t know if they will all three fit in” (p. 96); a third child, in the course of being helped to write her name, was told that an “m” has “two humps” (p. 64); a fourth child being told that it’s not the correct time to collect her cousin from school as she is there “till three o’clock. It’s only about half past one now” (p. 165).

On the other hand, some of the mothers, particularly those from working-class backgrounds, also gave explicit lessons in mathematics, mostly dealing with numbers and counting; these mothers seemed concerned that the children were not getting sufficient formal lessons in their nursery schools. They were certainly correct in their supposition that the nursery school teachers viewed their role as providing the types of play materials that would help the children learn, in the course of their play, but as not explicitly teaching these concepts except as a part of drawing the children’s attention to concepts that the teachers (but not necessarily the children) felt were relevant. One of the problems of this study is that although we know that children clearly were involved in mathematics we have no information on just how frequently they were involved.

This lacuna is filled, in part, by Aubrey, Bottle, and Godfrey (2003) who conducted an analysis similar to that of Tizard and Hughes (1984), although drawing on the transcript corpus collected originally in Bristol by Gordon Wells (1984), mentioned earlier. As Aubrey and her colleagues noted, the Wells corpus had been examined only from the point of view of children’s language, and they examined it for its mathematical content. The original data were gathered from 128 English children from the age of 15 months until they reached five, with 24 30-second recordings done between nine in the morning and six in the evening every three months. Unlike in the case of Tizard and Hughes’ research, no observer was present; researchers returned to the home in the evening in order to play back the tape and get information about the context.
Aubrey et al. (2003) examined the transcripts of 10 of the children, across a wide range of social classes, and found that about 2% of the sampled conversations at 30 months contained some reference to mathematics, and that the amount of mathematics increased (approximately 2.3% each month) as the children got older. Approximately 2/3 of the language was related to numbers and counting, and most of the rest to measuring things. Of course, as the authors note, this method made it impossible for mathematical activities in the absence of speech to be recorded, and therefore “it is quite possible that activity without interaction was underestimated” (p. 96). Interestingly, although some of the parents were clearly trying to teach the child, and used a didactic style of language, and although others simply incorporated their mathematical language in the context of the games that the children were playing, most of the mathematical utterances came from the child and led to no comment on the part of anyone else.

This may seem surprising to those used to working in laboratory settings, in which mothers (particularly from middle-class backgrounds) tend to talk to their children a lot. Gelman, Massey, and McManus (1991) used an ingenious method to assess parent-child interactions around mathematics, by observing informally in a museum—a situation in which the observers appeared to be museum staff. Of particular interest was an exhibit set up by the actual museum staff specifically to help children with number, although the children who attended would be likely (most being pre-literate) to require adult help to read the signs (such as “how many headlights on a car?”) that the exhibitors had displayed in order to encourage parents and children to talk about number. Gelman et al. (1991) found that the exhibit was popular, with approximately 400 visitors during a 3-month period. However, during the observational periods, only one-third of the parents actually read aloud the “how many” question, and only 19% counted or encouraged their children to count, while another third did not interact with their children at all. Gelman and her colleagues used these findings to point out that “adults—who surely are able to interact so as to encourage their children’s interest in number activities—do not always choose to do so” (p. 237), particularly in situations in which they do not think that they are being observed for research purposes!

A number of scholars have also tried to determine the extent to which children are engaged in mathematics in some type of childcare or preschool setting. However, just as we know relatively little about children’s naturally occurring mathematics at home, so too “very little is known about the nature and frequency of mathematical input in preschool classrooms” (Klibanoff et al., 2006, p. 59). As Baroody and his colleagues (2006) note, one should not expect a great deal of math to occur there, given many
early childhood teachers’ lack of comfort in providing mathematical instruction to young children.

This view certainly seems to have been born out by Tizard and Hughes’ (1984) observations in the nursery school classrooms in which the three-year-olds in their study spent their mornings. The teachers, when interviewed, would talk about providing relevant materials with which the children could play, such as “the provision of vessels of different size and shape for water play [to help] the child to develop concepts of volume” (p. 182). Compared to the home setting, the children’s likelihood of conversing with the teachers was far less, and the conversations themselves far more limited and, apparently, confusing to the children than Tizard and Hughes found at home. Very few instances were reported of a teacher communicating with a child about anything mathematical.

Klibanoff et al. (2006) examined hour-long transcripts of preschool teachers’ talk in their classrooms, and found that on average the teachers provided some type of “math input” (the authors focused solely on number, rather than other aspects of mathematics) 28 times during the hour. However, the teachers varied widely in the extent of their input, ranging from one to 104 times, and also varied widely in the type of input, from counting and use of number symbols to ordering and calculation. Some of this mathematics is the sort of activity that parents or teachers, being asked about how they were spending their time, would have noted, such as when one of the teachers asked the children to help her count days on the calendar, or when another asked a child “Nine, what comes after nine?” (Klibanoff et al., p. 63). But other comments would almost certainly not have been noted in the same way, as for example a teacher said that three children could help her, or mentioned a story (The three little pigs) that they had read.

Although audiotape is a good means of picking up the sort of detail that is missed by live observation alone, we should be concerned by those studies that are based solely on audiotaped recordings, as they necessarily miss all examples of children’s mathematical experiences that occur in the absence of conversation or verbal commentary, thus underestimating the extent to which children are involved in mathematics. This hypothesis seems to be clearly supported by those rather few studies that use videotape as a way of assessing children’s involvement with things mathematical.

**Videotaped Observations of Young Children’s Everyday Mathematics**

Aubrey and her colleagues (2003), whose analysis of Wells’ audiotaped data was discussed earlier, also collected their own data in Coventry, using
video to record the activities in and around the home for one hour, every four months, from the second year of life until the children started school (typically, in England, in the months before turning five years of age). They reported data on two of the nine children in the study, hoping that “the disturbance of the observer over time was minimal as parents and children appeared to ignore the video... [although] the parents admitted that they had probably paid more attention to their children during the observation period than was usual” (Aubrey et al., p. 97). Data analyses were based on five-minute segments, and dialog related to mathematics occurred in almost 50% of the segments of both girls when they were 30 months (the same age as with the data derived from Wells’ transcripts). Obviously this is far higher than the extent of mathematics conversation found in the Wells data (2%). In part this difference may be due to the presence of a camera, but in addition the segments used in the analyses were well over three times longer, thereby allowing more mathematical language to be found per segment in the Aubrey et al. study.

The rate of monthly increase was far greater in the case of one child (3.6%) than the other (0.6%), and Aubrey and her colleagues (2003) explain that in part because of the different ways in which the mothers of the two children thought about encouraging mathematical understanding during the course of the children’s play. However, it was also the case that the mother of only the first child participated in a lot of her child’s imaginative games and was skilled “not only in capturing and holding the young child’s interest, but in encouraging, supporting and even challenging her mathematically” (p. 101). These differences in practices led to the first child, when she had reached four years of age, being involved in mathematical dialog in close to all of the five-minute segments, compared to a little more than 50% of the segments in the case of the other girl.

Mathematical dialog, of course, is only a subset of mathematical experience and, as mentioned above, misses all nonverbal engagement in mathematics. It was thus a shame that Aubrey et al. (2003) used their videotape as others have used audiotape. By contrast Ginsburg and his colleagues (Ginsburg, Inoue, & Seo, 1999; Ginsburg et al., 2003; Seo & Ginsburg, 2004), in a series of studies using videotape, have made a powerful argument that “young children engage in a considerable amount of mathematical activity during their free play” (Seo & Ginsburg, 2004, p. 95). The methodology in each of these studies involved the videotaping of children, aged four and five, in their preschool classes, focusing on a single child for 15 minutes. The tapes were then analyzed, in one-minute segments, for the presence and type of mathematical experience. The codes for type of mathematical activity were not imposed in advance, but derived from the tapes, and included classification, magnitude, enumeration, dynamics, pattern and shape, and spatial relations. The study began with 30 children, from low-
income Black and Latino families, in a childcare center in which Ginsburg and his colleagues had a long-standing working relationship, which allowed the children to be very comfortable with the researchers’ presence (see Ginsburg et al., 1999). Seo and Ginsburg, however, reported on a total of 90 children, drawn from five different centers and encompassing equal numbers of low income, middle income, and high income children, and similar numbers of Blacks (31), Latinos (25), and Whites (34, 30 of whom were from a single center and were classified as high income).

The results were striking in that 88% of the children engaged in at least one math-related activity during the course of the 15-minute videotaping, and on average the children engaged in at least one such activity in 43% of the one-minute segments. Seo and Ginsburg (2004) reported that there were no significant differences in the extent of involvement by income level (the range was approximately 40% to 44% across each group) or gender (boys 41.3%, girls 43.5%). Across all groups the children were most likely to be involved in activities using pattern or shape, followed by magnitude and enumeration.

Ginsburg et al. (2003) expanded on this study, drawing on a total of 24 children from Taipei, Taiwan and 60 children from four of the childcare centers in New York (the 30 upper-income White children did not feature in these analyses). The Chinese children were equally divided by social class, with middle-class families defined as those in which parents had professional occupations. As noted above, the American children were involved in mathematical activities in just under 45% of the one-minute segments; those from Taiwan, however, were involved in mathematics in about 70% of the segments (73% in the middle-class sample, 63% in the working-class sample). Although the children engaged in classifying, comparing size, and enumerating to quite similar extents in both countries, the Chinese children were far more likely to be involved with pattern and shape (49% vs. 21% of their activities) and in spatial relations (15% vs. 3%).

It thus appears that children are involved in mathematics once or twice a day when parents are asked to respond about their children’s typically occurring activities, perhaps twenty times a day when observers study children’s naturally occurring activities, or half the time when researchers videotape children’s activities and then code for any type of involvement with mathematics, including cases when mathematics is not the focus of attention. We (Li, Kinney, & Tudge, 2005) wondered whether Ginsburg and his colleagues might have overestimated the extent to which children typically engaged in mathematics by filming in some childcare centers in which they had a long-standing relationship (Ginsburg et al., 1999). Our question was whether children would be as likely to engage in mathematics in their everyday lives outside of childcare.
As described above, Tudge and his colleagues (Tudge & Doucet; Tudge et al., in press) collected 18 hours of data in the course of live coding in any of the settings in which the children in their samples were situated. They then observed for a further one to two hours, using videotape. The observational system was set up in such a way that the final two hours of direct (non-filmed) observation occurred outside of a childcare setting so that filming could immediately follow without the researchers needing to get additional permission to film within a childcare center. The great advantage of this approach was that the children, and those who interacted with them on a regular basis, were already used to the presence of the observer and, except in very isolated incidents, appeared to continue to behave as naturally as they had done previously.

We utilized the same coding scheme and methods that Ginsburg et al. (2003) had used, with the exception that we added one category (planning, or the idea that one thing is going to occur after another) which was derived inductively, as was the case with the original coding scheme, from examining our videos. We analyzed the tapes from 16 three-year-old children, evenly balanced by race/ethnicity (White and Black), social class (parents with and without professional occupations and higher education), and gender, dividing tapes into one-minute segments and coding whether or not mathematics occurred and the type of mathematics. Reliability was assessed on half the tapes, and kappas were consistently above 0.7.

Given the results of the live coding reported in Tudge and Doucet (2004), we were surprised to find that the children were involved in a good deal of mathematics. Overall it was less than that reported by Ginsburg et al. (2003), namely 36% rather than 44%, but this was perhaps to be expected given that the filming occurred in settings that were not specifically set up to help educate young children. Unlike Ginsburg and his colleagues, however, we also found some clear differences between the children based on their race/ethnicity and social class (but not gender). The working-class Black and middle-class White children were involved, on average, in about 45% of the minute-long segments, but the working-class White children were only involved in mathematics in approximately 33% of the segments and their middle-class Black counterparts in 17%. Given the small numbers of participants, some caution is clearly needed before interpreting these racial/ethnic and social class differences. The other major difference between our data and those of Ginsburg and his colleagues is that enumeration was the type of mathematics in which the children were most likely to be involved (more than 20% of the segments) and the White children were also quite likely to be involved in the mathematics of magnitude (about 12%); the children were not particularly likely to be involved in pattern and shape (less than 5%). It may of course be the case that childcare settings are more likely to have easier access to materials...
involving specific patterns and shapes than are the other settings in which children find themselves.

At and around the home, of course, many opportunities for mathematics present themselves in the course of typically occurring activities. For example, Georgina (a pseudonym), a middle-class White three-year-old is helping her mother bake cookies: “Hand me a little spoon,” she says. “No,” replies her mother, “You need a big spoon” and later tells her daughter that she needs to “mix it one more time.” When it is time to pour the mixture into the containers it is clear that Georgina is occupied in estimating how much material is needed to fill the spaces, even though nothing is said explicitly about it. A little later, her mother helps her to plan her time by asking a couple of times whether Georgina wants to eat and then take a bath or bathe first and then, after her daughter has finished eating says that they can read “just one story” before taking a bath. Within the story itself there are various opportunities for Georgina to experience number and time, such as when her mother reads: “The hands [on the village clock] always pointed to 20 minutes to 4” (CEYC field notes 0107). For other children, experiencing mathematics, particularly number, occurred in very different ways. For example, a middle-class Black three-year-old, Kevin, spent a good deal of time playing with a computer at home, and among the games he played was one that required him to match the written number (on a turtle’s back) with the number of eggs in a nest. A little later, he listened first to a computer-generated song involving numbers and then to one about shapes and then, for about five minutes, responded to computer-generated questions about “what number comes after...?” This was then followed by a game in which he created a picture by pressing on the number representing the correct answer to simple addition questions. Kevin’s mother’s role is restricted to suggesting that he might try the next level of difficulty, and then to explaining that he needs to wait while the computer loads. Kevin does wait, and while doing so plays with some blocks, helping his older sister fit them into the correct spaces (CEYC field notes 0302).

We were still somewhat surprised that the children were involved in as much mathematics as they appeared to be, despite the fact that the amount of mathematical activity was not much less than that reported by Ginsburg and his colleagues (2003). We wondered whether the specific method that has been used to identify the occurrence of some type of mathematical activity, namely its presence or absence during a one-minute period (five minutes, in the case of Aubrey et al., 2003) serves to overestimate the extent of children’s involvement as the method does not tell us whether engaging in mathematics happened for the entire minute or only briefly within the minute. For this reason we decided to calculate the precise time each child was involved with something mathematical. These
results cut by almost exactly half the amount of time that the children were actually engaged in mathematics, from approximately 40% of the minute-long segments to 20% of the time in the case of the White children, and from 32% of the minutes to 17% of the time in the case of the Black children (Li et al., 2005). It is also important to mention, however, that the average involvement in mathematics disguises rather large individual differences, as Aubrey and her colleagues found—some children are much more likely to be involved than are others. In our data, for example, some children were observed engaging in things mathematical during only 1% of the videotaped observations, and others as much as 48% of the time observed.

CONCLUSION

The methods that scholars have used to assess the extent to which young children are involved in mathematics in the course of their everyday activities are clearly implicated in the data that have been obtained. Relying on parents to report on how much mathematics their children are involved in is clearly inadequate. However, no greater reliance should be placed on methods that only attend either to mathematical discourse (in the case of those studies that rely on audiotape) or to the activities that appear to be the primary focus of the child’s attention and which fail to take into account the extent to which one or other aspect of mathematics is being used to achieve some other, non-mathematical, goal. Parents’ reports and these more general observational approaches seem to under-represent significantly children’s informal engagement in mathematics given the extent to which it can be captured on videotape by researchers who have spent sufficient time with the participants to allow them to behave, insofar as can be ascertained, as they would have if the camera-wielding observer had not been present. It is also worth noting that only researchers who use videotapes can examine children’s activities in sufficient detail to be able to describe the types and quality of children’s mathematical experiences, and not simply the extent of that experience.

Contrasting even the most generous parental estimates or researchers’ live observations of the extent to which children engage in mathematical activities with what can be seen when their everyday activities are videotaped is clearly supportive of Piaget’s position that preschoolers’ experiences with objects and shapes and the exploration of space and time without any explicit teaching by adults provide innumerable opportunities for children to build on as they develop their understanding of conservation of number, length, volume, and so on. As Piaget argued, young children do not learn mathematics by being taught; they learn in the course of
their experiences in and of the world. These experiences by no means require adult support or teaching; Ginsburg’s and our CEYC videotapes show children being involved in mathematics alone or in the company of other children. It may be the case, as Tizard and Hughes (1986), Munn and Schaffer (1993), and Baroody et al. (2006) point out, that both in Britain and in the United States teachers of preschool-aged children do not involve their children in much mathematics, but this clearly does not stop children from gaining potentially rich mathematical experiences without depending on adult support, contrary to what Munn and Schaffer had reported.

Nonetheless, one cannot downplay the role of adults. As is clear from much of the observational research as well as those studies that rely on parents’ reports, other people (particularly mothers, at home, as noted by Tizard and Hughes, 1986) clearly support young children’s learning of mathematics by involving them in mathematically-related activities, encouraging them to count, estimate, talk about time, and so much more. It is tempting to contrast Piaget’s stress on the child as active experiencer with Vygotsky’s emphasis on the critical role the sociocultural world plays in children’s development. Nonetheless, this would be a mistake, given that Piaget clearly did not discount the role of parents and teachers but merely argued that they should spend their time questioning and encouraging curiosity rather than trying to impose understanding prematurely. Similarly, Vygotsky by no means ignored children’s own active involvement in coming to understand the world they are living in. In our CEYC videotapes it is clear that much of the mathematics that young children are involved in occur, as we showed in the case of Kevin, because of the children’s own initiation of the activity. In Kevin’s case, of course, that interest was clearly mediated by technology that has been made available for him by his parents and by virtue of living in a society that has access to this type of technology. Thus, as Vygotsky’s theory predicts, children’s engagement in mathematics seems intimately related to the typical social practices in which they are involved.

In cases in which the surrounding social world not only provides mathematically-relevant objects and situations but also people who draw attention to them and encourage children to explore and think about them we should not be surprised that children develop mathematical skills to a greater extent than when those conditions are relatively lacking. It is thus not surprising that the “competence” that children subsequently demonstrate is remarkably variable. As Sophian (1999) argued, this might explain why children can apparently be shown to demonstrate more sophisticated mathematical reasoning than Piaget predicted once problems have been presented to them in ways that fit within a context that makes more sense to them, but who do not show such reasoning once the context has been
altered. As Sophian wrote, “children’s knowledge, especially in its earliest forms, is closely tied to their understanding of the real-world interactions and activities in which they take part” (pp. 16–17).

Children, clearly, are involved in a good deal of everyday mathematics; however, the evidence is most likely to be gained when one looks carefully for mathematics in everyday life. This has implications for scholars and their choice of methods, but also has implications for parents and for teachers of young children. There are plenty of opportunities to help children with their growing understanding, perhaps simply by attending more closely to what they are doing mathematically, perhaps by helping create a zone of proximal development, or perhaps (as Piaget said) by suggesting “such counterexamples that the child’s new exploration will lead him to correct himself” (1973, p. 86). Parents and early childhood educators are happy to play a large role in young children’s growing awareness and enjoyment of literacy; it is unfortunate that they appear to treat things mathematical as being a less important part of children’s experience or something that should be left until children start formal schooling. No doubt children’s understanding of mathematical principles is growing as they engage in the types of mathematical experiences that can be seen on videotape, but there is also no doubt that both parents and educators could do far more to encourage and extend these mathematical explorations. After all, as Vygotsky argued, the type of mathematics that children learn “naturally” needs to be culturally mediated, and this might best be achieved by adults taking a less didactic role and instead encouraging the creation of zones of proximal development in conjunction with young children.

NOTE

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Impact of Method on Assessing Young Children’s Mathematical Experiences


