# ONLY TWO MORE SLEEPS UNTIL THE SCHOOL HOLIDAYS: ONE CHILD'S HOME EXPERIENCES OF MEASUREMENT

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Many children arrive at school with significant mathematical understandings (Clemson & Clemson, 1994). The challenge for teachers is how to build on this "rich base of mathematical experiences in ways that acknowledge and support the family's role" (Clarke & Robbins, 2004). To do this, it is necessary to understand how mathematics is used in the home and how experiences of mathematics change as children grow older. Most research into mathematical practices at home has concentrated on young children, generally preschoolers, and number concepts (Vandermaas-Peeler, 2008; Gifford, 2004; Clarke & Robbins, 2004). Once children start school, less is known about the types of activities done at home and how they could connect into school mathematics learning. Although measurement activities appear in the data of some projects (*e.g.* Clarke & Robbins, 2004), implications from this data for school mathematics teaching rarely are discussed explicitly. In this paper, I examine a six/seven year old child's interactions about measurement at home over the course of twenty weeks. Discussions of time were some of the few occasions where units were used and the only occasions where units were compared and contrasted. Yet it has been suggested that the concept of units of measurement should first be taught through other attributes such as length (NZ Ministry of Education, 2007). Consequently, there is a need to query assumptions about how to introduce measurement ideas.

In reviewing the literature on differences between mathematics learning at home and at school, Street, Baker & Tomlin (2005) have suggested that rich and poor children begin school with similar levels of informal numeracy understandings. However, this informal set of understandings only translates into being able to do school numeracy if the practices from which they were drawn were structured similarly. Consequently, poor children's performance in numeracy fell further behind their rich peers, the longer that they attended school. To investigate this issue further, Street *et al.* (2005) developed the *ideological model of numeracy* to describe why there might be differences between home and school numeracy practices. Numeracy practices are "broad notions about the ways numeracy is dealt with in different contexts and settings" (Street, *et al.*, 2005, p. 21). Table 1 draws from Street *et al.*'s (2005) descriptions of the four inter-related dimensions of the model.

This model provides insights into whether a simple transfer of mathematical practices can occur between home and school, or whether differences between home and school matter. For example, in an earlier paper, I discussed how a child seemed to have more control in her interactions at home than she did at school (Meaney, 2008). This may have been because different power relations existed at home compared to those at school. Street *et al.* (2005) have argued that "content, ideas and values and social and institutional relations are all infused by relations of power" (p. 22). Therefore, the dimensions of the model can provide useful insights into why differences occur and the sorts of discussions that are needed if home mathematical practices are to be acknowledged in school.

| Dimensions | Description |
|---|---|
| Content | The activities, techniques, procedures and processes of numeracy that individuals engage in. (p. 21) |
| Context | The framing of those occasions when numeracy is done and the purposes for that use of mathematics. (p. 22) |
| Values and Beliefs | The ways that individuals' beliefs, values and epistemologies affect the numeracy practices that they adopt. (p. 22) |
| Social and Institutional Relations | The kinds of control exerted over content, management of context and invoking of values and ideology exercised by different institutions and roles. (p. 22) |

*Table 1. Dimensions from the ideological model of numeracy (based on Street et al., 2005)*

Although the influence of context, values and beliefs, and social and institutional relations is reasonably well known (Benigno and Ellis, 2008), the influence of content, such as measurement, is not so clear. Hence, exploring measurement as one form of numeracy practices used at home is a rich area for investigation.

## Measurement and young children

Understandings about measurement have been based tradi-

tionally on work by Piaget and Inhelder with colleagues (Piaget, Inhelder & Szeminska, 1960). This work focussed on three ideas: transitivity, iteration, and the use of identical units (Bush, 2009). *Transitive reasoning* refers to "the ability to reason logically that if *A* is equal to the length indicated on the strip and the length indicated on the strip is equal to *B* then *A* and *B* can be inferred as being equal" (Kamii, 2006, p 154). Children are described as not yet having an understanding of transitive reasoning if they need to directly compare the two objects, A and B. *Iteration* requires students to recognise that items can be measured by units that are part of larger units (Castle & Needham, 2007). For example, children can compare the length of two desks by counting the number of hand spans for each desk. Their hand span is the smaller unit within the larger unit of a desk. However, children also must realise that the *units need to be identical* (Bush, 2009). If two children swap between their different hands to measure the length of a desk then they have not realised the need for the units to be the same.

Piaget's descriptions of children's development progressions have been criticised by a variety of researchers. In the 1970s, the Laboratory of Comparative Human Cognition (1979) warned of the cultural bias inherent in a model developed from a small number of Western children. In reviewing the research on children's development of understandings about time, Burny, Valcke and Desoete (2009) "found that growing up in a different culture results in distinct cognitive temporal structures that reflect differences in time-related conceptions, perceptions and attitudes" (p 482). Nevertheless, most mathematics curricula continue to base the teaching of measurement on understandings of transitivity, iteration and identical units. Perhaps unsurprisingly, numerous researchers have also documented children's struggles with measurement (Castle & Needham, 2007; Kamii, 2006; Tyminski, Weilbacher, Lenburg & Brown, 2008). Tyminski *et al.* (2008) suggested that children may learn the skills of measurement at school, but do not have many opportunities to develop conceptual understanding:

> For example, when children measure length by counting along a ruler, they may not be aware of what they are actually counting. Children may count the numbers on the ruler but may not necessarily understand that they are actually counting *the spaces between* the numbers (Tyminski *et al*, 2008, p. 34)

Consequently, suggestions have been made about how the teaching of measurement can be improved (Kamii, 2006; Castle & Needham, 2007). Buys and de Moor (2008) described the "basic pattern of the learning-teaching trajectory" (p. 23) for measurement as having three stages:

- measuring through comparing and ordering
- measuring through pacing off using a measurement unit
- measuring through reading off with the help of a measuring instrument (p. 25)

Time, and especially reading analogue clock time, is considered to be difficult for children (Hoodless, 2002) and can take several years to master (Burny *et al*, 2009). The ideas of transitivity, unit iteration and the use of identical units are needed for telling the time. However, children have limited visual or tactile information to support their learning. As Burny *et al.* (2009) have stated, children need to "develop a sense for the duration of an hour, a minute and a second and have to learn how these durations relate to each other and are related to their personal embodied experience of what an hour, a minute or a second feels like" (p. 468). These understandings must then be related to what they see happening on a clock. In order to read an analogue clock, children need to be able to count, do modular arithmetic and use fractions, make sense of angles in relation to areas on a clockface, understand and use the appropriate terminology for describing specific times, visualise movements of the different hands as well as understand what are arbitrary rules and what are consistent rules (Burny *et al*, 2009). Given the complexity and inter-relatedness of the skills and understandings, it is not surprising that learning to tell the time takes many years. Whilst previous research has concentrated on what occurs at school, almost nothing is known about how children and their caregivers work together to develop these skills and understandings at home. Using Street *et al* 's (2005) ideological model of numeracy practices, I examine the numeracy practices within the measurement activities completed at home by one child.

## Researching measurement activities in the home

The research described in this article is based on the interactions of a six/seven year old child, who was recorded for one day a week, for twenty weeks, in the second half of 2005. From when she woke in the morning until she went to school, the child wore a lapel microphone connected to a digital voice recorder. She was also recorded during her mathematics lessons. After she was collected from school, the child wore the voice recorder until she went to bed. The child's parents were Samoan speakers but English was the primary language spoken at home. The mother, who was the research assistant, organised the recording of the child's interactions. She listened to all the recordings and sent to a transcriber those which seemed relevant. The mother had experience as a high school English teacher in New Zealand and Samoa. I had got to know her and her daughter some years earlier when I had been teaching linguistics at the University of Otago.

The mother's awareness of the purpose of the project may have influenced the types of activities done at home. However, the recordings suggest that most of the time the child seemed unaware that she was being recorded. Although the data is extensive, it cannot be said that every kind of measurement activity that the child engaged in was captured over this 20 week time period. Like all research projects, the analysis is based on the data collected, leaving room for more research.

The data set was analysed by first noting any reference to mathematical practices. In looking at the transcripts for the twenty days, measurement was a mathematical activity that was discussed almost every week. The regularity of these discussions was related to the mother's explicit teaching of the child to read an analogue clock, as well as talking about other measurement topics.

## Talking about amounts

The numeracy practices undertaken by the child at home involved interactions around attributes such as height, depth, volume, space, mass, heat, speed, tightness, strength, loudness, and amount. Although in this article, I have concentrated on measurement ideas, it is likely that these were not the only learning that the child took away from these interactions (see Lange & Meaney, 2010, for a discussion of the child's non-mathematical learning in mathematics lessons). Many of these attributes would not be formally discussed at school, yet there were links to ideas about direct and indirect comparisons. In this section, I describe some of the child's measurement interactions at home and discuss how they could be interpreted as examples of transitivity, iteration, and the use of identical units.

Transitive reasoning involves the use of one object, a referent, to make an indirect comparison between at least two other objects. Until children gain transitive reasoning, it is presumed that they need to do direct comparisons. In the transcripts, there were few instances where direct or indirect comparisons were mentioned explicitly. Instead many of the interactions used specific amounts, such as "big girl", "little girl" (Week 3) which implied a comparison with an undiscussed norm. There were few uses of comparative expressions, such as "bigger than" or "more than". One of these was when the child discussed the death of a friend's pet rabbit: "she was too old and older, and she was really old, and she got dead" (Week 8). The lack of comparative language suggests that the child engaged in few interactions where transitive reasoning was required, even if she appeared to have moved beyond needing to put items side by side. Indirect comparisons did appeared in relationship to actions such as "turn the volume down" (Week 2). This is seen in the transcript from Week 3, where an indirect comparison was made in relationship to the child's brother being too tall to walk under a table:

Mother: Oh come here, ah you bumped your head. Oh dear, oh dear. Did you see he bumped his head? Watch where you're going. You're tall, see you're too tall to walk under that

Child: Then he went on the ground, he went like this, mum

Mother: Oh, he fell down. He used to be able to just walk under it because he was short but now ..

The height of the table acted as the referent between the toddler's present and past height and it was the action of walking under that enabled the comparison to be made. Actions were fundamental components of the numeracy practices where measurement was the focus.

Comparisons also appeared as a continuum of amounts, often through the addition of "bit" in expressions, such as "a bit chilly". In Week 8, there was a discussion about how something's mass could result in the popping of an air-filled cushion, as found in a jumping castle. Different animals are discussed, showing a sense of ordering the animals according to their varying masses. The lines indicate where speech was not clear enough to be transcribed.

Mother: I thought the one [activity] that you jump on the blue cushion would've been fun.

Child: Too bad you're not a child.

Mother: ___ blue cushion.

Child: 'Cause then you'll pop it. [Mum laughs]

Mother: I'm not that heavy, it's a big cushion. Father would pop it, not me, I'm not fat.

Child: ___ .

Mother: Who do you think? Maybe someone as big as a whale

Child: A whale would really pop it

Mother: If a whale jumped on it, it would definitely pop.

Child: And we'd all get hurt

Mother: If an elephant jumped on it, it might pop.

Child: Then we might all get hurt.

Mother: What other animal do you think might pop it?

Child: Giraffes wouldn't. What about antelope?

It is the ability to pop the cushion that is used for comparing the masses of the different animals. Imaginative conversations such as this suggest that the child had a sophisticated sense of transitivity. She was able to talk about whether her mother or different animals such as giraffes and antelopes would pop the cushion. She was also willing to discuss how the popping by a whale would result in harm, whereas an elephant bursting the cushion "might" result in harm.

Iteration and understandings about the need for identical units were not evident in many of the transcripts. Units were used to describe the amount of something, but more often than not, these were whole units, "two, three big teaspoons" (Week 18). The child could use iteration of a unit to measure something, but as making a chocolate drink was an inexact art, it is unlikely that she would have seen the need to ensure that the units were the same.

In a school situation, researchers such as Castle and Needham (2007) suggest that the focus has been on how to measure. At home, the focus for this child was measuring in a context. Measurement discussions were not an end in themselves, but were connected to events and so to sets of actions, either real or imagined.

## Time

Of all the attributes, time was talked about more often and for longer periods. Hoodless (2002) found in her study that six/seven year old children were "very precise about their timings and use of time-related vocabulary in reasoning" (p. 185) and this also seemed to be the case for the child in my study as well.

Like the other attributes, there were examples involving implicit comparisons of time, which may have helped the child to gain a sense of the duration of events. For example in the Week 5 transcripts, the mother wanted to go out:

Mother: What time does that program finish? Does it take long?

Child: No, not very long.

Mother: Good

A sense of what constituted a "not very long" time was confirmed when the mother did not have to repeat her question or insist that they leave in order to meet her deadline. If she had had to hassle then the child would have been made aware that the "not very long" time was too long.

Although there were no discussions about why some activities took longer or shorter periods of time than other activities, there were occasions when the time taken for certain activities was discussed. These discussions introduced the connection between labels for amounts of time and their experience of the durations of events. The following exchange came from Week 7:

Mother: Alright, you do need to think Child, to stop us from being late all the time, what time do you think you should get up in the morning?

Child: 6 o'clock.

Mother: (Amazed and unbelieving sound) Six, but you don't have to be at school until 9? Wouldn't that be too early?

Child: Don't worry, just stay there until it opens.

Mother: That's three hours before 9 o'clock, it's too early

Child: How about 7?

Mother: That's not too bad. How long does it take you to get ready, like, get your clothes on and brush your teeth?

Child: Well I'm not sure about 7 o'clock, because that's the time when you get ready, and 8 o'clock was when it's only two things we do.

Mother: What?

Child: Just all we have to do is, you know, you do my hair and do my face

Mother: What about breakfast?

Child: Yeah, we'd, it'd, um, 7 o'clock we do breakfast

Mother: You don't eat breakfast until you're dressed.

Child: Yeah, then, dressed, break.., I mean, brush your teeth, breakfast, ___ and then do my hair, face, yeah. Is that, is there anything else?

Mother: Shoes?

Child: Do my shoes up.

Mother: Pack your bag.

Child: Pack my bag and then go

Mother: Alright, so then what time do you get up in the morning?

Child: Still 7 o'clock

Mother: 7 o'clock. Are you sure you can do that?

Child: I'm not sure

Mother: (laughs) You can try. Well if you can't, 7.30 is alright.

Child: Yeah, 7.30.

Mother: Because it's not too early.

Child: Let's go at 7.30.

Mother: No that's when you wake up. Wake up at 7 or 7.30? I think 7.30 is realistic, because we used to do that, and by the time it's 8.30 you'll just be eating and ready to go, and you would have finished eating.

In this conversation, it seemed that the mother expected that the child had a sense of the duration of events and could relate these to standard units of time. Although the child knew that time is discussed in relationship to o'clock, she did not seem to have a sense of how these time markers related to units of an hour or how long different events took. On the other hand, she did appear to know what Friedman and Laycock (1989) labelled "temporal 'location' of a clock time within a day or the daily order of clock times" (p. 358). She knew that six o'clock was well before school began and that seven and eight o'clock came between six o'clock and the start of the school day. Therefore, she showed that she knew how to count, but not what she was counting, when describing the time that different activities took. However, it is clear that this child was engaged in discussions around the duration of different events while she was at home. The same transcript also shows that the sequencing of events was tied into the discussion of the duration of events and their connection to o'clock times. In time discussions, the order of different activities does matter in a way that putting together different objects to determine their overall length does not. Some events, such as getting dressed, occur before others such as eating your breakfast.

As the year went on, there were more discussions around specific units of time – minutes, hours, days, weeks, months, seasons and years. For example, whilst watching television, during week 9, the child said to herself "Only two more sleeps until school holidays". In this comment, she showed an understanding of transitivity, in that she could compare the amount of time before the holidays began as well as an understanding of iterations, even if the unit of iteration was a non-standard unit, "sleeps".

Over the course of the study, the mother began teaching her daughter how to read both an analogue clock and a digital clock. By the end of the year, the child had almost mastered the analogue clock. The following extract comes from Week 13.

Mother: Child, come and see what time it is by looking at the clock.

Child: Something to 9

Mother: Good girl. How many minutes? Can you count?

Child: Mmm. Oh wait. Can I have it down because I can't see it properly?

Mother: You only ___ __ under 12. How many dots are in between that little space?

Child: 5?

Mother: Yeah - good! Now what does that tell you? 5 what. What does that mean?

Child: 5 to 9.

Mother: Good girl. 5 what to 9? 5 hours? 5 .

Child: Minutes?

Mother: Good girl. 5 minutes to 9. Because what happens when the big hand gets to the 12?

Child: It means that it's 9 o'clock.

Mother: Good girl. See - you're learning fast. If the long hand was on the 1, it would be . . and the little hand ___ ___

Child: It would be 1 past 9.

Mother: Are you sure it would be 1 past 9? How many minutes is the gap?

Child: Oh no. That gap is. . 5?

Mother: Yeah

Child: 5 past 9.

Mother: What if the long hand was on the 2?

Child: It would be 10 past 9

Mother: Good - and what if it was on the 3?

Child: Yeah, but 15 isn't on it.

Mother: No - you can't see 15, but each gap, remember, is 5. So it's like 5, 10, 15

Child: Oh, so it does count 15?

Mother: Yeah!

Child: Oh. Is it 15 past 9?

The child was in the process of grasping the mechanics of reading a clock. She had the appropriate language and was able to use her number understandings. The mother also focussed the child on the gaps between the numbers on the clock. In school, there was no direct teaching of reading a clock - measurement was covered by doing activities on mass. Yet, it was something that the mother felt should be taught at home, possibly as a need to support the child arriving at school on time. At this point, the teaching of the mechanics of telling the time did not seem to be connected to conceptual understandings of transitivity and iteration. Later conversations during the second half of 2005 suggested that the child was simultaneously learning about the duration and sequencing of different events and how to connect them to specific amounts of time, such as hours and minutes. Combining these different understandings together so that the child could read an analogue clock took many months

## Discussion

Although this research looks only at the interactions of one child in a home situation, it raises a number of points. If we assume that the conversations were typical of what occurred for this child, then why was it that time, an abstract attribute, was the one which was discussed most often? Buys and de Moor (2008) suggested that length is the most primary of physical quantities to measure. This is because "[n]ot only is it available to children's perception, it is the most indicative quantity people want to find out about all sorts of objects" (p. 18). However, length was discussed only once in relationship to the child's brother being too tall to fit under a table.

Using Street *et al.*'s (2005) ideological model of numeracy, the *content* was measurement, in particular measurement of time. The *context* was the home, where measurement activities emphasised the relationship between the attributes and actions or events. In the discussions about time, for example, the *context* supported connections to actions such as decorations coming down because the child's birthday was over, but going up again for Christmas. Discussions about measurements in the school transcripts concentrated on skills development rather than on problem solving through actions. Therefore, the context did affect how an activity was framed (Benigno & Ellis, 2008).

The *social and institutional relations* determine what are considered to be "normal conversations" at home. The mother clearly believed that the child should learn about time at home and that she should take on the role of the teacher. The other social and institutional relation that influenced why time became important was that the child was constantly late for school. This affected how the child and her family were perceived by the teacher and the school more generally. In order to continue to be seen as a "good" family who supported the child's education, attempts were made to improve the situation, such as the discussion in Week 7. For the child to contribute to ensuring she arrived before the bell, she needed to be able to read a clock.

Having accepted the need for the child to learn about time and specifically how to read a clock, the mother made some decisions, most likely unconsciously, about how to teach it. The mother used a "school-like" discourse to teach her daughter how to read a clock. Although the mother was an experienced secondary school English teacher, it is unlikely that she would have taught any of her students how to read a clock. However, she did have a school discourse to draw upon. Thus, the mother's values and beliefs about how telling time should be learnt were influenced by the schooling context, even though the interactions occurred at home.

In some interactions, an implicit comparison about time was made in the same way that it was about other attributes. However, the abstract nature of time meant that discussions involved referring to specific units - years, months, weeks, days, hours, and minutes. Getting a sense of the duration of time (Buys & de Moor, 2008) requires children to become familiar with units of time and how they are related. In this situation, content interacted with context, values and beliefs and social and institutional relations. The abstract nature of time contributed to it being discussed explicitly. Other measurement attributes were part of an activity and so were not discussed explicitly. The social institutional relations may

have influenced the mother's decision to teach time to her daughter and this contributed to explicit discussions occurring regularly. To do this, the mother then drew on a school-like discourse for the teaching interactions. Her values and beliefs about how time should be taught were probably developed from her own experiences of learning time but also her work as a teacher

## Using home mathematical practices in school

Much research into measurement teaching and learning for young children has focussed on length (Kamii, 2006; Castle & Needham, 2007; Bush, 2009; Tyminski *et al.*, 2008) Analysis of the transcripts in this research suggests that we cannot assume that children have had many experiences at home in relationship to length However, family discussions around other attributes are likely to contribute to children developing understandings of transitivity, iterations and units of iterations. Theoretical understandings about these were based on children doing direct or indirect comparisons. Yet, this child's comparisons were often made with respect to undiscussed norms, sometimes in imaginative scenarios. For this child, time was prominent, probably because her continual lateness at school meant that she and her family were not meeting societal expectations. For other children, it may be different circumstances that affect what measurement attribute is given prominence. As Rogoff (1990, p 49) stated, it is parents and other adults who "determine the activities in which children's participation is allowed or discouraged, such as chores, parental work and recreational activities, television shows, the birth of a sibling, or the death of a grandparent". This is because children need to be acculturated into the behaviours expected of adult members of a community from an early age (Kearins, 1991). Teachers could benefit from talking to students' families about the measurement contexts in their homes. This would enable teachers to build their measurement activities around typical problems that children meet at home, rather than simply focussing them on skills development.

The home is a rich source of inspiration for the development of measurement tasks In the transcripts, the variety of attributes that were discussed was likely to support the child to engage in informal ways with measurement concepts, such as transitivity and iteration Interactions around measurable attributes were connected to actions. However, the problem-solving focus of many home interactions meant that the child may have had less opportunity to consider why the units should be the same when used to measure. Time, because of its abstract nature, meant that this child was introduced to formal units and the relationship between different units such as seconds and minutes. We, therefore, cannot presume that just because an attribute is abstract that it will be more difficult for children to grasp.

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