HOW ONE PRESCHOOL TEACHER RECOGNISES MATHEMATICAL TEACHING MOMENTS

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Currently there is much discussion internationally about what and how mathematics should be integrated into preschool programs. In Swedish preschools, there is a strong tradition of children's play. Using video data, we identify how one teacher in a Swedish preschool recognises and builds on mathematical teaching moments that arise from children's play. The role of respectful listening and asking challenging questions is important in the development of children's mathematical curiosity. We use this data to explore whether using teaching moments is an appropriate teaching practice in preschools for ensuring that children have good mathematical knowledge to begin school with.

MATHEMATICS THROUGH PLAY IN SWEDISH PRESCHOOLS

Happy hearts and happy faces,

Happy play in grassy places--

That was how in ancient ages,

Children grew to kings and sages.

(Robert Louis Stevenson, *A child's garden of verse Poem XXVII Good and bad children*)

It is not compulsory for young children in Sweden, yet by 2008 more than 90 percent of children, aged 2 to 5 years, attended preschools (2010). Although other Western countries also increased the number of preschools to meet parental demands, the systematic intervention of the government in providing not just physical spaces but also highly educated staff is considered unique to Sweden (Broman, 2010). Within the recently revised curriculum for preschools, emphasis is given to the role of play in encouraging learning, including the learning of mathematical concepts (Skolverket, 2011). In this paper, we explore how one teacher develops children's mathematical thinking from their play. Through respectful listening, including watching carefully what children do, the teacher is able to ask questions that simultaneously push children's mathematical curiosity and support their play.

Play is considered the foundation for preschool children's learning experiences. In the revised version of the Swedish preschool curriculum, play has a central role as the medium through which children are expected to learn.

> Play is important for the child's development and learning. Conscious use of play to promote the development and learning of each individual child should always be present in preschool activities. Play and enjoyment in learning in all its various forms stimulate the imagination, insight, communication and the ability to think symbolically, as well as the ability to co-operate and solve problems. (Skolverket, 2011, p. 6)

In Swedish, to play in a situation without rules is "lek" and this is the form of play mentioned in the curriculum. Play is acknowledged as being difficult to define (Samuelsson & Carlsson, 2008). Dockett and Perry's (2010) definition combines many of the features also identified by Samuelsson and Carlsson (2008):

> The process of play is characterised by a non-literal 'what if' approach to thinking, where multiple end points or outcomes are possible. In other words, play generates situations where there is no one 'right' answer. … Essential characteristics of play then, include the exercise of choice, non-literal approaches, multiple possible outcomes and acknowledgement of the competence of players. These characteristics apply to the processes of play, regardless of the content. (Dockett & Perry, 2010, p. 175)

In preschools, there are predominantly two kinds of play, free play, in which children uses the resources around them without adult intervention, and guided play where a teacher sets up a situation but allows children's own interests to guide the play. As well, direct teaching can occur in preschools. In this case, the teacher prescribes what actions the children can do. Children may still enjoy this learning but they can make limited, if any, choices about what they do (see Emilson & Folkesson, 2006).

Although it has been documented that mathematical learning has arisen from free play (Coltman, Petyaeva, & Anghileri, 2002), Lee and Ginsberg (2009) suggested that children are likely to gain only limited mathematical understandings from it. Consequently, the role of the teacher is of paramount importance. Björklund (2008) showed that adults set the parameters for children's opportunities to engage with mathematical ideas. As well, an adult watching or participating in child-initiated play can develop children's mathematical ideas by stimulating their curiosity and language use (Doverborg, 2006).

In this paper, we first present two models about the organisation of learning before describing in some detail, how the Swedish preschool teacher engaged with a small group of children around the mathematical ideas in a set of glass jars. We then use the models to analyse the teacher's role in developing children's mathematical curiosity through building on mathematical teaching moments.

THE ROLE OF THE ADULT IN PRESCHOOL CHILDREN'S LEARNING

In discussions of the support that adults, such as teachers, provide children the importance of scaffolding, where adults gradually reduce their level of support so children become competent, is often raised. Frequently, this discussion is framed in relation to children solving problems (Wood, Bruner, & Ross, 1976). Using her own and others' work on scaffolding, Anghileri (2006) distinguished between different teacher strategies for scaffolding mathematics learning. These strategies can be seen in the three level model of Figure 1 and the levels are considered to be hierarchical in their relationship. Anghileri (2006) stated:

> At the most basic level, *environmental provisions* enable learning to take place without the direct intervention of the teacher. The subsequent two levels identify teacher interactions

that are increasingly directed to developing richness in the support of mathematical learning through *explaining*, *reviewing and reviewing* and *developing conceptual thinking*. (p. 38)

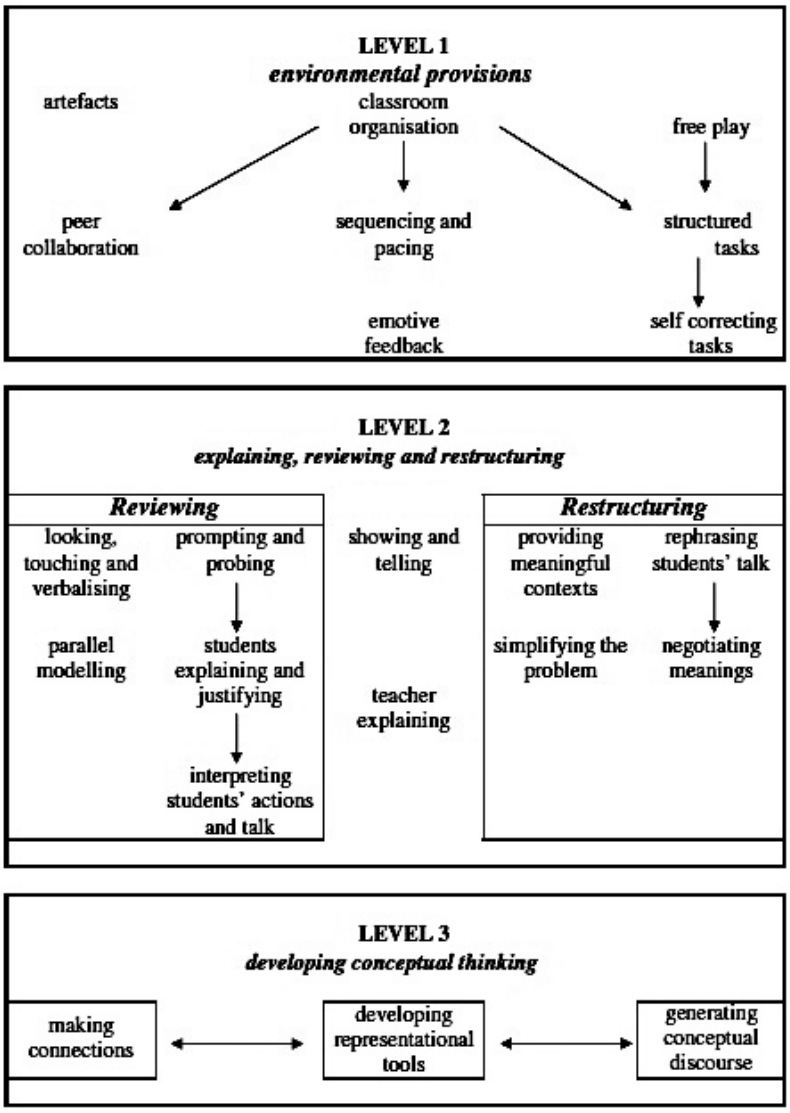

Figure 1: Teacher strategies for scaffolding learning (from Anghileri, 2006, p. 39)

Examples of different strategies are provided at each level. The strategies in the centre of each level are those that Anghileri (2006) considered to be seen more frequently in classrooms, while the strategies on the sides were the ones that were likely to be connected to effective mathematics classrooms. Although situated within the school context, much of the work that Anghilera drew on in developing this model came from research on 4-6 year olds. Given that Swedish children are in preschools for most of this age period, Anghilera's model is a valuable resource in trying to understand the teacher's role in developing children's mathematical curiosity.

Nevertheless, Anghileri's model focuses on what the teacher does and the children's actions are not visible. In a study of toddlers in a Swedish preschool, Emilson and Folkesson (2006) used the ideas of Bernstein to suggest that a teacher, "instead of

keeping control by the selection of communication, its sequencing and its pacing, she is responsive, observant and confirming, and she develops the ideas of the children" (p. 237). In so doing she was able to support children to make decisions about their learning and consequently be involved in genuine participation. The child's contribution to the interaction was the basis on which learning opportunities were developed. Therefore, a model focused on the role of the teacher is unlikely to be sufficient to describe how a teacher builds on children's play to develop their mathematical curiosity.

In many ways the description of this teacher's interactions with toddlers resembles what Rogoff, Paradise, Arauz, Correa-Chávez and Angelillo (2003) described as *intent participation*. Although they acknowledge that there are many ways to organise learning, in their article they distinguished between *intent participation* and *assembly-line instruction*, which they perceived as being more common in schools. Figure 2 shows the main differences as described by Rogoff et al. (2003). These differences result from *intent participation* being commonly used when "people engage together in a common endeavour" (p. 183) and *assembly-line instruction* being used when there is a "transmission of information from experts outside the context of purposeful, productive activity" (p. 183).

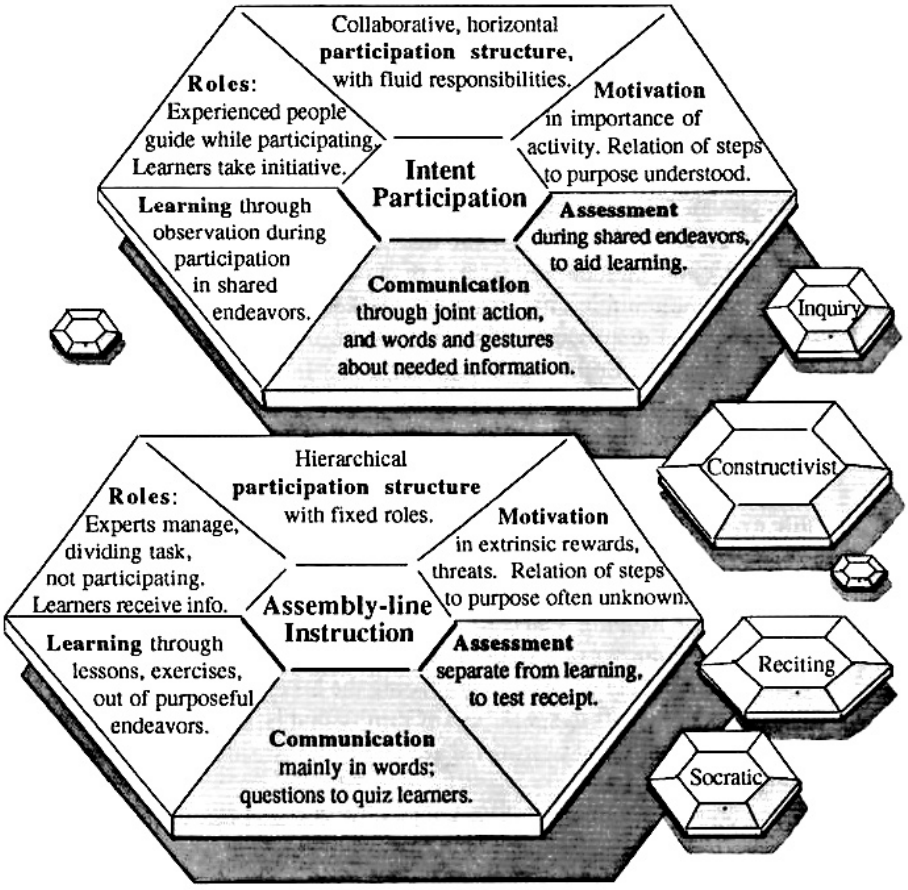

Figure 2: Multifaceted traditions for organizing learning (from Rogoff, Paradise, Arauz, Correa-Chávez, & Angelillo, 2003, p. 185)

Although not specifically on preschool teaching, Rogoff et al.'s (2003) model, like that of Anghileri (2006), drew on extracts from interactions between adults and preschool children to exemplify the different components. They considered that it is the integration of the components which contribute to the different traditions for organising learning. Certainly the components of *intent participation* recognise the role of the child or learner in the interaction. There is an overlap in some aspects of both models; for example, Anghileri's model highlighted the need for a teacher to identify meaningful contexts whilst Rogoff et al. suggested that in *intent participation*, "motivation is generally inherent in the obvious importance and interest of the activity". However, there are also differences. Anghileri concentrates on the teacher, while Rogoff et al. view the roles of the participants as being fluid.

METHODOLOGY

The research was undertaken in a private preschool in a large city in southern part of Sweden. Filming was undertaken with different classes/groups over several days. In this paper we report on one episode of guided play. Although originally the teacher had not nominated it as being an activity focussed on mathematics, this focus became evident as the children engaged with the jars. Therefore, this episode was chosen because it exemplified how the activity was built around the children's own interests. The whole episode lasted about 9 minutes. Extracts of the transcript are provided in the original Swedish with an English translation.

After first describing the episode, we then analyse how the teacher identifies and then elaborates on children's interests by discussing each of the components in Rogoff et al.'s multifaceted models. We then elaborate on these components by using examples from the activity to make connections to Anghileri's (2006)'s teacher strategies scaffolding for learning.

PLAYING WITH GLASS JARS

In this episode, three children, Marie, Mia and Lena, all pseudonyms, are playing with glass jars. The teacher (L in the transcripts) provided the opportunity because they will later put coloured paper on the jars to make them into candleholders.

The teacher placed herself on the side of the group of three girls. The teacher was at the same height as the children and this contributed to the girls focussing on the jars which were in the centre of the space. The children continually touched the jars, putting their hands and feet inside and interchanging the jars between themselves. At only one point during the episode did the teacher come close to touching the jars and this was when she pointed to one in order to highlight a difference between it and another jar. Although the teacher asked questions, she did not model answers, nor push the children to answer her questions when they showed reluctance. It could be said that she guides the children's actions, but is respectful of the children's control over the direction of the activity.

The teacher began by asking the children if they thought that the jars looked the same. The children explained how they perceived the different jars as rectangular, thick or thin. The teacher opened up the space for learning by asking one of the children, Lena, why she thought her jar was thick.

L: Och din är lite tjock. På vad sätt är den tjock Lena, hur är den tjock?

L: And yours is a bit thick. In what way is it thick Lena, how is it thick?

Lena: Den är tjock på denna bredden. [barnet har en burk som blir tjockare nertill som hon visar på]

Lena: It is thick at this width. [the child has a jar that gets thicker at the bottom as she demonstrates]

The teacher then continued by contrasting different shapes.

L: Har den någon annan form någon annanstans?

L: Does it have any other shape elsewhere?

This helped the children to notice different shapes both between the jars as well as within the jar. After a while the teachers opened another space for learning by asking if they could put the jars in some sort of order. Lena placed all but one in a pile and explained how it was rectangular and therefore did not fit with the others.

After a short while, Mia tried to put her foot in one of the jars and Lena and Marie copied her.

This went on until the teacher again asked the children if they could put the jars in order but this time she specified that the order had to be according to size. The children started to place them in order with the teacher guiding them with questions.

L: Vilken kan komma efter den här om den är högst och sen kommer den vilken kan komma efter den här? [Marie flyttar dit en högre burk] Om man tänker att man hitta nått som är lägre än den?

L: What can come after if this is the tallest and then what could come after this? [Marie moving a taller jar into the line] Do you think that you could find one that is lower than that?

Marie: Större.

Marie: Bigger.

L: Den är högre.

L: It is taller.

[Mia ändrar på burkarna så att de går från högre till lägre]

Mia changes the jars so they go from tallest to shortest.

On the initiative of Marie they divided the jars between them. Marie said that everyone could have two each. The teacher then asked if they could have three each.

L: Om vi gör, så att vi ställer tillbaka dom också ser vi om vi alla kan få, ställ tillbaka dom Marie allihopa, om alla kan få tre var?

L: If we do, so we set them back to see if we can all get, set them back Marie everybody, if anyone can get three of them?

Marie: En, två, tre [Marie räknar när hon tar sina, de andra bara tar]

Marie: One, two, three [Marie counts as she takes hers, the others just take theirs]

…

…

L: Det gick inte att få tre var.

L: Could not get three each.

Then they counted the jars, Marie counts to seven whilst Lena counts to eight.

L: Åtta. Hur många fick du det till, kommer du ihåg det? [till Marie] när du räknade alla tillsammans? [Marie skakar på huvudet]

L: Eight. How many did you get it, do you remember that? [Marie] when you counted all together? [Marie shakes her head]

Marie: Sju.

Marie: Seven

By contrasting the answers the teacher makes them aware that there were two different answers. However, Marie did not want to take this any further and said that she got eight as well.

Again the teacher wanted them to put the jars in order but this time with the small jars in one pile and the tall ones in another pile. Although it began as a discussion about size, all of a sudden Marie says *fyrhörning* (meaning a figure with four corners) or a quadrilateral. The teacher picked that up and they started to talk about the different shapes instead.

Throughout the episode, the teacher followed whatever the children showed an interest in. However, the repeated requests, for the jars to be ordered according to size, suggested that she did have a specific intention for the activity. Yet, she followed the children's own interests and did not insist on them continuing to arrange the bottles according to different kinds of orders. By being sensitive to the children's interest in the jars she both catches and misses opportunities to challenge the children's understanding.

ANALYSIS

Rogoff et al. (2003) described six different components for organizing learning. In this section we go through each one of these, making connections to Anghileri's strategies where appropriate.

Participation structures

The teacher set out the jars in order to have the children make candle holders. Possibly because the children began to handle the jars immediately, she invited the children to play with them. At different times, she requested the children to talk about the jars and to order them in different ways. However, in responding to the teacher's suggestions the girls took control of how the activity developed through their actions or comments. Although the participation structures did not have the fluidity described by Rogoff et al. (2003) for *intent participation*, neither did they have the fixed roles of the *assembly-line instruction*. The teacher set up the activity but she provided the space for the children to take control and was willing to follow what they were interested in.

This fluidity of control was supported by "provision of artefacts", a scaffolding strategy, from the *environmental provision* level, which was the lowest level of

Anghileri's (2006) hierarchy. The provision of artefacts, the glass jars, scaffolded the children into learning. The jars attracted and retained the children's interest and consequently they explored them in a variety of different ways, sometimes with teacher guidance but also by themselves. Level two of Anghileri's (2006) teacher strategies identified "looking, touching and verbalising". The provision of the jars resulted in the children immediately touching and playing with them. The teacher could build on these tactile sensations by asking different children to verbalise what they noticed, thus bringing mathematical ideas such as shape and number into focus.

At times the children engaged with the jars individually, or in parallel, but at other times they worked together as was the case when they ordered the jars from shortest to tallest. According to Anghileri (2006), the provision of grouping as a way of working together is a form of scaffolding at the environmental provision level. Children working together in this way, with the teacher on the side, was a result of collaborative, horizontal participation structures, but it also supported the use of those structures.

Roles

In *intent participation,* "experienced people play a guiding role, facilitating learners' involvement and often participating alongside learners – indeed often learning themselves. New learners in turn take initiative in learning and contributing to shared endeavours, sometimes offering leadership in the process" (Rogoff et al., 2003, p. 187). In the activity, the teacher did not participate in the same way that the children did and so her role was closer to that of manager in *assembly-line instruction*. Yet, although she suggested activities, such as ordering the jars, she did not force the children to carry them out. As well, the children took the initiative in suggesting activities and so their role could be considered to be closer to that of *intent participation*. They used the ideas of each other as much as they did the ideas of the teacher to structure their interactions. Although they did not verbally interact with each other like they did with the teacher, they constantly watched each other and copied their actions.

After Marie suggested that everyone could have two jars each, the teacher challenged them to see if it was possible for them to have three jars each. Many of the teacher's questions focused the children on mathematical aspects of their jars. As part of her level 2 strategies, Anghileri (2006) identified the need for teachers "to interject questions that focus on the most critical points in an explanation and take the understanding forward. Here the purpose is to gain insight into students' thinking, promoting their autonomy and underpinning the mathematical understanding that is generated" (p. 42-43). Without the questions, these aspects may have been missed by the children. Therefore, the teacher's role as the one with expert knowledge was important.

Although the teacher may have known the answers to some of her questions, her way of listening to the children indicated that she was opening a learning space for their

children's reflections. Thus, it was not just the teacher asked prompting and probing questions but also that she left the children to interpret and answer the questions, which meant that children's autonomy was supported. Thus, her "listening" style was as important as her questioning style.

Motivation and purpose

The teacher suggested that the tasks, in which the children were to engage, were one of play – "Men innan vi börjar med att göra dem här ljusen tänkte jag att vi kunde leka lite med de här burkarna. Tycker ni att alla burkar ser likadana ut?" (But before we start making the candles here, I thought we could play around with these jars. Do you think that all the jars look alike?". The video of the episode showed that the children did indeed play around with the jars, even though the teacher began with a school-like question. The characteristics of play identified by Dockett and Perry (2010), "the exercise of choice, non-literal approaches, multiple possible outcomes and acknowledgement of the competence of players" (p. 175) can be seen in how the children explored the jars. Consequently, the motivation and purpose of the activity was clear to all. By agreeing on the activity being one of play, the children were free to make choices about what they would do. It would not have been appropriate for the teacher to ask questions in a school-like Initiation-Reply-Evaluation format (Rogoff et al., 2003) as this would have clearly changed the activity. With everyone conforming their actions to those consistent with play, the result was that the children responded by engaging eagerly.

However, with the activity being play, many of the teacher scaffolding strategies suggested by Anghileri (2006) were inappropriate unless they were adapted to suit the play situation, such had been the case with teacher listening. One of Anghileri's level two strategies is that of "identifying meaningful contexts" but this is focussed on finding a shared context which can make the mathematical problem more accessible to the students. Nevertheless, this episode with preschool children suggests that working in a context that is meaningful for the children and conforming to the characteristics of that context, play, ensures that children engage actively.

Sources of Learning

Rogoff et al. (2003) suggested that "in intent participation, learning is based on participation in ongoing or anticipated activities, with keen observation and listening" (p. 22). The glass jar activity was not an adult activity where the children learnt from watching experts. Just reading the transcript of the episode could suggest that the children merely responded to the teacher's questions as would be the case in *assembly-line instruction*. However, the pictures show that as well as listening to the teacher, the children actively engaged in manipulating glass jars and watching another child. Simultaneously noticing different behaviours is common in play where the focus shifts quickly. Therefore, as in *intent participation*, the children paid attention to multiple ongoing events. In *assembly-line instruction* the focus is usually on only one action with children who focus widely, labelled as being distracted and

likely to have problems learning (Rogoff et al., 2003). Thus, because the activity was acknowledged as play, focusing widely provided the sources of learning.

With the children focusing widely, there are opportunities for them to make connections between visual imagery and spoken words, a scaffolding strategy, developing representational tools, that Anghileri (2006) saw as being part of Level 3. Mia used the discussion between Marie and the teacher about "bigger" and "taller" as well as looking at and touching the jars themselves when she rearranged the glass jars from smallest to tallest.

Forms of communication

In the episode, the children's actions were often connected to language as a result of the teacher's questions. As discussed previously, the teacher's questions were sometimes about information that she already knew. As such, Rogoff et al. (2003) would consider that they were test questions and a form of communication linked to *assembly-line instruction*. Yet the children responded to them as though they required genuine investigation. For example, the first request was about whether the children thought the jars were alike. Although the children and the teacher could see that there were differences, the children picked up the jars, felt them and then made comments about them. The teacher was not judgemental about the comments, but instead asked for further clarification. She did not push any child to respond, as was the case with the counting of the jars. Although this format for interaction could not be considered typical of *intent participation* where the expert provides explanations only within the context of the process being learnt, it has much strength in making the mathematics visible in the exchange but keeping the conversation within the children's control.

All of Anghileri's (2006) scaffolding strategies can be considered forms of communication as they were concerned with how a teacher interacts with students and as already noted, many of them are visible in this episode. In the highest level of scaffolding, Anghileri describes "generating conceptual discourse" in which the teacher identifies for the students valuable ways of thinking mathematically, "thus enabling students to become aware of more sophisticated forms of mathematical reasoning" (p. 49). The teacher's requests for clarifications rather than judging the children's answers would contribute to children coming to see that their explanations was what the teacher valued, rather than a specific, correct answer. This is likely to contribute to them gaining "intellectual autonomy" (p. 49).

Assessment

In *intent participation*, assessment occurs continually during the performance of the activity with the intention of ensuring that children gain "the important skills and ways of their community" (Rogoff et al., 2003, p. 196). By being in a play situation, assessment requirements are neither connected to the performance of a particular practice nor to determining children's retention of set information, as is the case in *assembly-line instruction*. Yet the preschool teacher was involved in continual assessment both of the children's willingness to engage, important in *intent*

participation, but also of the mathematical information that they showed. Within the play situation, the teacher could use this information to develop children's mathematical curiosity through further challenging questions. Having children show the mathematics that they knew was not an end in itself but rather contributed to the play being continued and the mathematics becoming visible.

Anghileri (2006) suggested that negotiating meaning is one strategy that involves the teacher having to listen carefully.

> It is time consuming and demanding on a teacher's skills to elicit the true meaning of their students' responses, respecting the more outlandish contributions as their students work at developing their personal understandings, and not simply opting for responses that are 'in tune' with their requirement. (Anghileri, 2006, p. 46)

Anghileri queries the need for teachers to insist that children always provide the "correct" meaning. When two children arrived at different final counts of the jars, the teacher raised that there were differences but when Marie did not want to discuss the difference, but changed her answer to that of Lena, the teacher did not insist on Marie recounting. The teacher could assess the children's knowledge and note for future reference that it might be useful to provide activities where it was likely that Marie would need to count to eight again. Requiring Marie to count immediately after she had rejected an offer to discuss her answer may have decreased her desire to willingly participate in further activities and changed the activity from one of play to one of direct teaching as would be the case in *assembly-line instruction*.

USING PLAY FOR TEACHING MATHEMATICS

At first glance, play and teaching mathematics do not seem to be compatible. Yet this example of a preschool interaction shows that play can provide rich opportunities for teaching mathematics. The teacher was able to stimulate children's mathematical curiosity about shapes, their attributes and about number, including division. This curiosity could be seen in the way that the children played with the jars and the mathematical ideas that they discussed.

Nevertheless, by placing the teaching in a play situation the teacher's actions are constrained in certain ways. As was illustrated in this episode with the glass jars, play means that children have as much opportunity, if not more, as the teacher to control the direction of the activity. The focus of the activity can switch and change frequently contributing to children taking note of a wide range of stimuli at the same time. The teacher can offer suggestions for activities and ask questions about what the children are engaged in but the children can ignore the invitation or decline to participate. The teacher cannot insist that her suggestions are accepted as this would move the activity from one of being play into something more closely resembling Rogoff et al.'s (2003) *assembly-line instruction*. Consequently, the teacher must watch and listen very carefully to the children so that her suggestions build on the children's interests. The questions and suggestions should raise the children's

curiosity, if children are to engage with them willingly. If the teacher is successful in doing this, then the mathematical aspects of children's actions are made visible.

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