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Pedagogical Documentation as Research in Early Mathematics

Pedagogical Documentation (PD) as a tool for curriculum development in early learning environments has emerged from the practices of the educators in Reggio Emilia, Italy (Cadwell, 2003). Researchers in the Math Education department of the University of British Columbia are interested in exploring children's authentic representations of their knowledge. They are conducting a pilot study to investigate the potential of using PD as a research method.

Context

Young children often express mathematical thinking in non-traditional ways (Baroody, 1987), and research has established that the most common methods of capturing informal mathematics greatly underrepresent children's experience of them (Tudge, 2009). Some have tried to address this issue by focusing on creative expression in math (Worthington, 2005) or capturing nonverbal data (Wolodko, 2005). Among its main purposes, PD serves to sensitize adults to the "100 languages" that children use to express their understandings (Rinaldi, 2001). It consists of both *content* (the collection of artifacts: photos, videos, children's art, transcriptions of conversations) and *process* (collaborative revisiting of experiences to promote reflection; mutual respect between all partners; creating visible documentation to communicate learning) (Cadwell, 2003). So far, PD has been used to capture the informal mathematics in preschool play (Perry, Dockett, & Harley, 2007) and as formative assessment in kindergarten (MacDonald, 2007). We are testing it with an exploration of primary-aged children's mathematical thinking.

Method and Results

Six children (5 yrs 7 mos-6 yrs 10 mos) participated in our pilot study. They met in pairs with one adult researcher (previously a teacher of theirs), who introduced each of the two 30-minute sessions with an invitation: "We can play, and while we're playing, you can show me some of the things you know about numbers and math." All sessions were videotaped and photographed for subsequent review.

Preliminary data analysis has revealed three distinct areas of interest:

1. Children spontaneously express the same math concept in multiple ways. We observed a pair of 6-year-olds exploring the concept of *half*. As they played with art materials, they drew half suns ("people can only see part of it"), cut squares down the middle ("this is half because they're both the same"), cut paper apples down the middle (and then rejected this as half because of the asymmetry of the fruit), and folded paper to make

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airplanes ("fold it carefully in half—that's how you know where the middle is"). The children were demonstrating their understanding of *half* in diverse contexts.

2. Children give observable evidence of incomplete mathematical understanding through their behavior and talk as they engage in creative activities. With regard to mathematical notation, for example, two children (from other pairs) incorrectly and consistently used an x to symbolize addition. One was using the calculator, simultaneously describing her actions as she pushed buttons and read the numerals on the screen. "One-ten plus one-ten equals." She had already told me that 10 + 10 = 20, and by attempting to represent this with the calculator, she articulated her incomplete understanding of place value.
3. If given time and space to do so, children explore meaningful links between mathematical ideas through their play. This was one of the strongest findings for our study. It addresses the process of pedagogical documentation where researcher and children alternate leading and following. At one point I had set up a game to investigate a child's understanding of *half* as it pertained to a group of objects (something that had not been spontaneously indicated). After the game and a short discussion about an apparent inconsistency in the use of the term (*half* can mean 3 apples; it can also mean one apple cut up), a child in the pair suddenly said, "I have an idea—let's make paper airplanes!" Under other circumstances a researcher might well have interrupted the child to continue her own investigation (I had a plan in mind to make a connection between the half apples and the quarter sun in the drawings). However, remaining true to the process of pedagogical documentation, I followed the child's lead and offered to take photos of their airplanes. The child fetched paper and went to the table. To my complete surprise, her first words of instruction were, "You have to fold it completely in half—that's how you know where the middle is." The strength of PD as a data-collection method was that it ensured that the process of exploration continued (out of my control), and, therefore, the child was free to explore at her own pace and in her own style. I submit that most other methods of data-collection may well have missed this opportunity.

Discussion

Although the above results show promise for capturing complex learning and thinking processes, the approach has a number of limitations. First, the process of PD necessitates a longitudinal approach. The nature of revisiting and exploring together with the children requires ongoing collaboration. Second, the process is labor-intensive, but perhaps no more so than other qualitative methods. Third, it will be most useful in domain-specific studies because of the vast amount of data that it produces. A future study is planned to address further these ideas and others.

As PD thus proves to be a productive method of data-gathering for young children's mathematical thinking, it holds potential to address a number of issues in math education research. For example, by making a visible connection between the concrete and the representational worlds, researchers may be able

to explore why children persist in regarding concrete materials and notation as disconnected (Fuson & Burghardt, 2003). Another area that could be investigated is the development of positive math dispositions such as risk-taking (Blair & Razza, 2007). PD is uniquely positioned to capture the significance of a complex process as it evolves over time.

As researchers continue to seek ways of authentically representing children's knowledge and understanding of math, our study informs and may stimulate a new approach.

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