Children noticing their own and others' mathematics in play

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Much is known about preschool children's mathematics learning and the role of play in that learning. Many early childhood educators are quite adept at observing and documenting the mathematics learning of the children in their settings. These teachers 'notice' the children's mathematics but they are not the only ones to 'notice'. In this paper, children's noticing of their own and others' mathematics is investigated through a pilot study of a small number of preschool and first-year-of-school children. Content analysis of observations and children's discussions with researchers provides the basis for the early development of an analytical framework for children's 'noticing' mathematics.

Introduction

It is well known that children learn a great deal of mathematics before they start school (Ginsburg, Lee, & Boyd, 2008; Hunting et al., 2012; Sarama & Clements, 2015). It is also known that children's early mathematics learning is likely to support their later achievement in mathematics (Duncan et al., 2007; Geary et al., 2013). Young children learn mathematics – and many other things – through a variety of pedagogical approaches, but one of the most likely is play (Hunting et al., 2012; Shonkoff & Phillips, 2000; Siraj-Blatchford & Sylva, 2004; van Oers, 2010).

As preschool children learn mathematics through play, their teachers are not passive in their efforts to facilitate that learning (Hunting et al., 2012; Moss, Bruce, & Bobis, 2016). In fact, much has been made of the finding that "unstructured play, by itself, is unlikely to provide sufficient support for young children's mathematical development" (Anthony & Walshaw, 2009, p. 110), with the consequent development of early childhood pedagogies such as 'intentional teaching' (Department of Education, Employment and Workplace Relations, 2009; Siraj-Blatchford & Sylva, 2004). In this paper, another tack is taken in terms of support that might be helpful with children's mathematical development – the paper investigates what it might mean for children to 'notice' their own and others' mathematics in the context of their play and what consequences this 'noticing' might have for their mathematics learning.

Literature Review

Part of an educator's role in an early childhood setting is to notice what children know and are learning about mathematics, how they come to understand this mathematics, and how they then put this knowledge into practice. Much has been written about how teachers pay attention to, and make sense of, what is happening in children's learning during mathematical experiences, including play (Breen et al., 2014; Jacobs, Lamb, & Philipp, 2010; Mason, 2002; Thomas et al., 2014/2015); van Es & Sherin, 2008; Wager, 2014). These activities are sometimes described as 'noticing' children's mathematics.

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'Noticing' children's learning is not a recent phenomenon (Erickson, 2011; Mason, 2002). To date, the research emphasis has been on teachers noticing children's mathematical learning. A number of analytical frameworks has been suggested. For example, Mason (2011) suggests that

> The discipline of noticing is a collection of techniques for (a) *pre-paring* to notice in the moment, that is, to have come to mind appropriately, and (b) *post-paring* by reflecting on the recent past to select what you want to notice or be sensitized to particularly, in order to *pare*, that is, to notice in the moment and so be enabled to act freshly rather than habitually. (pp. 37-38)

Building on Mason's 'discipline of noticing' and applying this to teachers noticing their children's mathematics, van Es and Sherin (2008, p. 245) describe a *Learning to Notice Framework,* consisting of three main components: "(a) identifying what is important in a teaching situation; (b) using what one knows about the context to reason about a situation; and (c) making connections between specific events and broader principles of teaching and learning". Jacobs et al. (2010) note that while many researchers have used the term 'noticing' to describe how mathematics teachers engage with their children's mathematics, "the connecting thread is making sense of how individuals process complex situations" (p. 171). They extend the work of others to develop the notion of 'professional noticing of children's mathematical thinking' with the "three related skills: attending to children's strategies, interpreting children's understandings, and deciding how to respond on the basis of children's understandings" (Jacobs et al. 2010, p. 172). A recent study by Wager (2014), used these constructs – attending, interpreting and responding - to examine the ways teachers noticed students' mathematical thinking and the relationship that the teachers saw with equitable pedagogy.

What educators and parents 'notice' about children's mathematics has been documented in the context of the *Let's Count* program (Gervasoni & Perry, 2015; Gervasoni, Perry, & Parish, 2015; MacDonald, 2015). The program highlights the importance of "noticing, naming and celebrating the mathematical understandings which young children develop" (MacDonald, 2015, p. 100).

Let's Count has encapsulated its descriptions of noticing by educators and parents through an adaptation of the Jacobs et al. (2010) and Wager (2014) frameworks to develop a mantra for the program: **notice, explore, and talk about children's mathematics**. While there are clear links between this mantra and the earlier professional noticing frameworks, the language in the mantra has been very helpful to early childhood educators and parents as they notice children's mathematics (Gervasoni & Perry, 2015). One aim of the study reported here is to explore the efficacy of applying this mantra to children noticing their own and others' mathematics. The significance of this level of 'noticing' lies in previous research showing that children who are able to engage metacognitively with their mathematics display greater mathematical knowledge and understanding than those who cannot (Ginsburg et al., 2008; Whitebread & Coltman, 2010).

Methodology

The study is an exploratory, pilot, qualitative study, which considers data from children in preschool and the first year of primary school. It had two aims: to gain insight into the ways 4-6 year-olds notice their own and others' mathematics; and to explore methods that might be appropriate to generate such data. This paper reports on the first aim.

The participants for the pilot study were drawn from two settings in a regional city in Australia. The first was a primary school where the children (4 boys and 2 girls) were in their first year of schooling. The second setting was a preschool where the children (3 boys

and 3 girls) all attended several days a week. The children in both settings came from a variety of socio-economic and family backgrounds, but all spoke English at home.

Over a six-month period of fortnightly visits to each setting, data were generated through a variety of methods, some of which were different in each setting. The decision to utilise different methods was based on the individual participants, their interests and responses, as well as the organisational structure of each setting. Methods employed at the primary school included Lego play, drawings, children's reflections – both immediate and delayed - on photos they had taken, and anecdotal observations of children as they engaged in play activities and discussion. Methods used in the preschool included reading and discussing picture books, drawing and discussing pictures, anecdotal observations, discussions with the children, block play, animal play, play dough play and outdoor free play. These were unobtrusive and/or familiar methods in each context and provided opportunities for children to demonstrate their understandings in a non-threatening environment. Much of the data was collected through discussions the researcher had with the children about what they were creating or playing. Data from both sites were analysed via content analysis (Bryman, 2008), using the *Notice, Explore* and *Talk About* mantra as the analytical frame.

Results and Discussion

In both the preschool and the school, these children **noticed** mathematics, **explored** this mathematics beyond the noticing and often, were disposed to **talk about** the explorations and the mathematics they encountered. On many occasions, the exploration was generated through an adult's (the researcher's) interest, but this was not always the case. In all the cases presented, further knowledge – and skills – either for the child or for the adult and, sometimes, for both – were **talked about**. The following examples highlight children's (sometimes implicit) noticing, exploring and talking about mathematics and the use of the mantra as a preliminary coding frame, rather than using, for example, a grounded theory approach to coding (Charmaz, 2014).

Example 1: School

The children and the researcher had an interactive discussion prior to this activity in which the children explained their understanding of what mathematics was and how this related to what they were currently learning in 'maths'. The six children were then each given a digital camera and asked to take photos outside; of anything they deemed to involve mathematics. The researcher printed copies of the photos and took them to the following visit – two weeks after they were taken. Conversations with the photographers focused on the mathematics evident to the children in these photographs and their reasoning for taking them. The photo in Figure 1 was taken by Annie. Her reasoning follows.

Figure 1. Annie's rainbows

Researcher: Tell me about this photo Annie.

Annie: They are pedals (pointing to the pedals). See those two round things there? (Pointing to the bike racks in the top left corner) They are semi circles. They are like rainbows. They are orange. They are the same shape.

This photograph and conversation highlights Annie's ability to notice, explore and talk about mathematics in the environment. Annie began by **noticing** the shape. She was then able to **explore** it through the use of photography and its relationship to something she knew – rainbows. Annie was able to **talk about** the mathematics she had explored, not only by naming the shape but also by comparing the shape she had noticed to the shape of the rainbow. Annie seems to have been able to see beyond the central object in the photo and notice the shapes in the background. Whether she saw these shapes when she took the photo or when she was shown the print is unknown, but this does not diminish the power of Annie's mathematical noticing.

Throughout the course of the project, other conversations with Annie demonstrated her ability to notice mathematics. For example, she talked about the detail of pictures she had drawn, describing some tree trunks as rectangles and commenting on different shapes in houses such as the windows (squares), doors (rectangle), and the roof (triangle).

Example 2: Preschool

Children do not always proclaim loudly that they have noticed some mathematics. Sometimes, their noticing is much more subtle. James was talking with the researcher about his family and how he would be **"**bigger soon … and then [I could] go to school like my brother. I am too small now to go". One could claim that, while James is talking about mathematical ideas and exploring their ramifications for him, he does not notice what he is using as mathematics. Perhaps this is so, but he does have a way of using mathematical ideas to gauge when he will be able to go to school. However, for James, help was at hand! On overhearing the conversation, Emily contributed "He can't go to school because he isn't as tall as his brother and them [the other children who go to school]". In this interaction, both James and Emily **notice** the applicability of mathematical ideas to everyday situations, **explore** these links and **talk about** the relationships using mathematical language.

Example 3: Preschool

During data collection, an iPhone was used as a voice recorder. One week, Charlie noticed the visualiser moving up and down as we spoke. The following is a small snippet of the conversation that followed:

Charlie: Oh cool! Your phone is counting.

Researcher: How did you know my phone was counting?

Charlie: Well I can see that the numbers are going up, see how they are going fast? Do you know how it will make a big loud bit and then you can make a small bit when you are not loud? Look BIG LOUD bit, small bit. [Charlie is referring to the sound visualiser varying due to the volume of the voice that it is receiving.]

Jack [who had been watching the visualiser for some time]: Look BIG LOUD bit, small bit. It changes when we talk. So if we talk really loud, it makes it so big; and if we whisper (whispering), it goes really small.

The framework: *Notice, Explore,* and *Talk About,* can be used to analyse this conversation. Charlie **noticed** the visualiser incidentally, being initially attracted by its

movement. He then **explored** the relationship between the motion of the visualiser and the pitch/volume of his voice. Jack joined the conversation and contributed his understanding of the relationship between his voice and the visualiser.

Example 4: School

Two girls were playing with flat, coloured blocks, creating what adults might call a 'mosaic'. Helga put a small red block in a large gap which meant that there was not enough room for any other blocks to fit in. Annie removed the block and said to Helga: "No you can't put that in there, it won't fit. There will be space left. We need to use this block [correct size block]." Annie removed the block that Helga had placed and put the correct fitting block into the spot. "Helga put another one in there that didn't fit so I had to take it out! I put one in there that fit!"

Annie **noticed** Helga's mathematics when she chose an inappropriate (at least, by Annie's reckoning) block. She then **explored** the possibilities among the remaining blocks and set about 'correcting' Helga's 'error'. Annie **talked about** the mathematics being used not only to Helga; she seemed driven to report it to some (unknown) authority as well.

Example 5: Preschool

The three preschool boys were playing in the construction area when the researcher asked them what they knew about numbers. The children talked about the places that they have seen numbers including the supermarket "On the shelves, so that you know how much you have to pay for things", and "On houses in the street so you know where you live, on clocks, on money, around our classroom, on my bedroom wall". The conversation then moved onto shapes.

Researcher: What about shapes? What shapes do you notice around you?

James: Here is a square, at the bottom of the lemon squeezer bottle.

Charlie: I can see the window and that's a square.

Jack: There is the shape of this. It's a triangle. Haha! Just tricking you, it's a square. It's a box.

James: Here is a circle. It's a vase that you put flowers into.

Charlie: Look at this shape. It's a diamond [Holding a square box on an angle].

Notice, Explore, and *Talk About* can be seen in this conversation as the children play with their own and others' ideas and 'joke' with the researcher.

Example 6: Preschool

Children notice the mathematics that other people, including their parents, do. Such noticing is evident in the following example.

Emily was drawing a picture.

Researcher: What are you drawing there Emily?

Emily: Ummm 4 and 5 and 6 and 1.

Researcher: Why are you drawing numbers? Have you seen anyone using those numbers?

Emily: Mum and Dad on the phone. I am drawing them using the phone. I have seen numbers on names as well when I look in their phones.

Emily's comments indicated that she had **noticed** her parents using mathematics, and had **explored** other places where mathematics was used.

Example 7: School

In response to the researcher's request to draw a time when he saw someone using mathematics, Jackson demonstrated his noticing of mathematics and the value of **talking about** it.

Jackson: I know what I am going to draw. I am going to draw Mum organising our trip, because she used lots of numbers when she had to do that.
Researcher: When was Mum using numbers?
Jackson: When she was seeing how much the flight was and seeing how much the hotels were and seeing how much money and other stuff we needed to have when we went to Cambodia and Thailand.

Example 8: Preschool

James had spent a great deal of time using blocks to make a zoo for all of the animals with which the children had been playing (Figure 2).

Figure 2. James' zoo

Researcher: James, how did you know to build this one [pointing to the rectangle block sitting on the flat roof], and then this one [pointing to the square block on top of the rectangle] and then this one? How did you know the order to build this in?
James: Because this one is the right size to fit that on there [pointing to the rectangular block], and then that's the right size to fit that one on there [pointing to the block on the very top]). So that's how they have all fitted together.
Researcher: Have you seen someone build like this before?
James: Yeah, I build things with Dad lots. He shows me how to build things like this.

James had **noticed** mathematics (how shapes fit together) and how his Dad built things using mathematics. He has **explored** with the blocks and was able to **talk about** all of this with the researcher. He showed his understanding of some mathematics and explained what had influenced this understanding.

Example 9: Preschool

The final example shows how children can **notice** the mathematics in their lives and use it to **explore** familiar aspects of those lives. They can then **talk about** it to each other in a natural but inquiring manner.

Charlie: like Summer, it's hot and you get to go in the pool.
Patsy: I know that there is Winter and it's cold and there is snow.
Annabelle: I go swimming when it's cold too though.
Jack: I am so good at swimming I am in the top level.

Conclusion

This exploratory study sought to gain insights into young children's noticing of their own and others' mathematics. Using methods familiar to the 4-6 year-old children, and appropriate to each context, the children provided evidence that they did notice mathematics in their daily interactions. In several cases, the labelling of the content as mathematics was driven by the researcher, and this prompted opportunities to explore and talk using mathematical language, and highlighting the mathematical understandings underpinning the interactions.

The children often noticed mathematics in their own play, in their peer's actions, and mathematics used by family members, as well as mathematics in their environment. It was apparent that children in their first year of school referenced the mathematics they were learning in school, prompting reflection on what might be considered to constitute 'mathematics' in each setting.

The study demonstrated that these children noticed their own as well as others' mathematics in a variety of different situations and scenarios. It also highlighted the importance of conversations with children about what they noticed. The *Notice, Explore* and *Talk About* mantra facilitated analysis of the children's experiences. The study prompts further investigation among larger groups of children in diverse contexts to explore the ways they notice, explore and talk about mathematics; ways in which adults (parents and teachers) facilitate this noticing; pedagogies that recognise, support and extend children's mathematical understandings; and conversations about what constitutes mathematics across different contexts. If teachers and other adults know more about how young children think and know about their mathematics, improved mathematical outcomes are likely to ensue (Anthony & Walshaw, 2007; Ginsburg et al., 2008; Moss et al., 2016).

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