‘Infinity Means it Goes on Forever’: Siblings’ Informal Teaching of Mathematics

Nina Howe\textsuperscript{a,*}, Emmanuelle Adrien\textsuperscript{a}, Sandra Della Porta\textsuperscript{a}, Stephanie Peccia\textsuperscript{a}, Holly Recchia\textsuperscript{a}, Helena P. Osana\textsuperscript{a} and Hildy Ross\textsuperscript{b}

\textsuperscript{a}Concordia University, Montreal, Québec Canada
\textsuperscript{b}University of Waterloo, Waterloo, Ontario Canada

Sibling-directed teaching of mathematical topics during naturalistic home interactions was investigated in 39 middle-class sibling dyads at two time points. At time 1 (T1), siblings were 2 and 4 years of age, and at time 2 (T2), siblings were 4 and 6 years of age. Intentional sequences of sibling-directed mathematical teaching were coded for (i) topics (e.g., number), (ii) contexts (e.g., play with materials/toys), and (iii) type of knowledge (conceptual and procedural). Siblings engaged in teaching number, geometry, and measurement at T1 and demonstrated preliminary evidence of teaching of grouping, relations, and operations at T2. Regarding context, at T1, mathematical teaching occurred most frequently during play with materials/toys, while at T2, games with rules were prominent. Teaching of conceptual or procedural knowledge varied over time and by topic and context. Findings are discussed in light of recent work on understanding children’s mathematical knowledge as it develops in the informal family context. Copyright © 2015 John Wiley & Sons, Ltd.

Key words: siblings; teaching; mathematics; informal learning; home context

Social constructivist learning theories are based on the premise that children’s development is facilitated by close and intimate relationships such as with parents and siblings (Carpendale & Lewis, 2004, 2006; Rogoff, 1998; Vygotsky, 1978). Informal (i.e., naturalistic) interactions between family members are an important context in which children gain an understanding of their social and physical worlds, particularly during sibling interactions (Dunn, 2002; Howe, Ross, &

\textsuperscript{*}Correspondence to: Nina Howe, Education Dept., Concordia University, Montreal, Québec, Canada, H3G-1M8.
E-mail: nina.howe@education.concordia.ca

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Recchia, 2011). Sibling relationships are characterized as affectively intense, and children spend considerable time playing and interacting, thus creating a meaningful context for transmitting knowledge to one another (Howe et al., 2011). In fact, young siblings are capable of teaching one another when researchers provide a semi-structured paradigm that calls directly for teaching, as well as during ongoing interactions at home (e.g., Azmitia & Hesser, 1993; Howe, Della Porta, Recchia, Funamoto, & Ross, 2015; Howe, Recchia, Della Porta, & Funamoto, 2012). Although preschoolers talk about mathematics to one another during free play in early childhood classrooms (Ginsburg, Lin, Ness, & Seo, 2003; Seo & Ginsburg, 2004), naturalistic sibling-directed teaching of mathematical content has received little systematic attention (Howe et al., 2015). Yet, Bryant and Nuñes (2014) argue that children are most likely to learn about mathematics during experiences and within contexts that are meaningful to them, presumably including the informal family context. A preliminary content analysis of children’s naturalistic teaching interactions at home indicated that mathematics was a frequent topic of youngsters’ instruction of their sibling (Howe, Della Porta, Scott, Osana, & Ross, 2011). Thus, the present study provided a more in-depth investigation of how siblings engage in the teaching of mathematical concepts during ongoing conversations and play at home over a 2-year period in early childhood. Specifically, we examined (i) frequency of mathematics teaching across the two time points, (ii) mathematical topics taught (e.g., number and geometry), (iii) teaching context (e.g., play with toys and games with rules), and (iv) associations with type of knowledge being taught (i.e., conceptual or procedural; Hatano & Inagaki, 1986; Rittle-Johnson & Siegler, 1998).

**Children’s Approaches to Teaching**

Social constructivist models view teaching and learning as bidirectional, collaborative exchanges between partners, where an imbalance of knowledge rather than authority is key to the process (Rogoff, 1998; Vygotsky, 1978). The teacher intentionally transfers knowledge or understanding to a less informed person (i.e., the learner) through guidance or more direct instruction (Frye & Ziv, 2005). Recent theorists argue that teaching is a natural cognitive activity that children do spontaneously and effortlessly as they transmit cultural knowledge to one another (Csibra & Gergely, 2009; Strauss & Ziv, 2012), which suggests that a careful investigation of the topics of naturalistic sibling teaching is warranted.

**Children Teaching Children: A Case for Sibling Teaching**

There is small literature on children teaching peers (e.g., Ashley & Tomasello, 1998; Wood, Wood, Ainsworth, & O’Malley, 1995; Ziv & Frye, 2004) and siblings teaching one another (e.g., Howe & Recchia, 2009; Howe et al., 2012; Pérez-Granados & Callanan, 1997). Given their long co-constructed history of frequent and affectively intense interactions, siblings are well placed to develop an intimate knowledge regarding one another’s skills, desires, and abilities (Dunn, 2002; Howe et al., 2011). Based on their greater knowledge and experience, older siblings often take the lead in teaching, whereas younger siblings are likely to be learners (Dunn, 1983). Teaching or the transfer of knowledge may also serve an important function during play; for example, a younger sibling may require some mathematical knowledge to play a board game so that the older sibling can continue what might be an interesting form of joint play.
In fact, a number of studies employing semi-structured paradigms have documented that by age 3, siblings can teach, and with time, they become more effective in conveying knowledge (Howe & Recchia, 2009). Over the preschool years, children are more likely to employ a range of scaffolding and direct instruction strategies to transfer knowledge to their sibling (Azmitia & Hesser, 1993; Recchia, Howe, & Alexander, 2009) and to vary their strategies according to task difficulty (Howe, Brody, & Recchia, 2006; Howe et al., 2012). While these studies illuminate many processes involved in children’s approaches to teaching, they rely on prior adult instruction to one sibling, thereby providing a possible model for the sibling teacher to use when instructing the learner.

In contrast, Howe et al. (2015) revealed a high incidence of intentional child-initiated teaching by 6-year-olds directed to their 4-year-old siblings during naturalistic ongoing interactions at home. Sibling teachers were most likely to initiate instruction about procedural knowledge (e.g., ‘knowing how’ to do something or achieve a specific goal; Hatano & Inagaki, 1986) and to employ demonstration and planning strategies to guide the learner to achieve a shared understanding of the task (e.g., how to write a number), whereas learners were more likely to request information about concepts (e.g., ‘knowing that/why’, so as to gain information, explanations, meanings, and relations about the world; Hatano & Inagaki, 1986). When learners requested teaching, sibling teachers engaged in explanations, clarifications, and discussions to convey the information clearly to learners, thus encouraging children to make predictions in unfamiliar contexts and develop new strategies for understanding. Interestingly, in contrast, most studies on sibling teaching employ semi-structured tasks requiring procedural knowledge (e.g., how to complete a puzzle) where one child is taught a task by the researcher and he/she is asked to teach his/her partner (Azmitia & Hesser, 1993; Recchia et al., 2009); less attention has been devoted to siblings’ teaching of concepts. A preliminary content analysis of the naturalistic teaching sequences revealed that approximately 30% involved mathematical topics and concepts (Howe et al., 2011), indicating that a more in-depth analysis was warranted. We now turn to the literature on young children’s understanding of mathematical concepts and why this domain would perhaps be one focus of their teaching.

Mathematical Knowledge and Development in Early Childhood

Prior to experiences with mathematics in preschool classrooms, children have already encountered and become familiar with certain mathematical concepts (e.g., Aubrey, Bottle, & Godfrey, 2003). Some authors have argued that infants may possess early numerical knowledge (Starkey & Cooper, 1980; Wynn, 1992; Xu & Spelke, 2000), although others have disputed these claims (e.g., Bryant & Núñez, 2014; Cohen & Marks, 2002); regardless, by age 2, children clearly have the desire and ability to learn mathematics (Ginsburg, Cannon, Eisenband, & Pappas, 2006; Sarama & Clements, 2009b). Preschoolers demonstrate early mathematical understanding regarding numeracy, geometry, and measurement concepts (Clements, 2004; Cross et al., 2009; Sarama & Clements, 2009b). Numeracy is defined as understanding and reasoning with numbers as reflected in children’s language and activities (Canadian Child Care Federation & Canadian Language and Literacy Research Network, 2010). Geometry involves knowledge of two-dimensional and three-dimensional shapes, their defining characteristics, and spatial transformations such as directions (Clements, 2004;
Cross, Woods, & Schweingruber, 2009). Early measurement concepts include understanding objects’ attributes (e.g., height) and the processes, techniques, and tools required to quantify these attributes (Clements, 2004; Cross et al., 2009). Preschoolers can also engage in basic algebra while working with patterns and performing analyses (i.e., classifying and representing; Clements, 2004).

Preschoolers’ early numeracy skills mostly focus on counting, but with formal schooling, the focus shifts to arithmetic (Lefevre et al., 2006), and children are introduced to the topics of operations, relations, and grouping as part of the kindergarten and grade 1 curriculum (e.g., Common Core State Standards Initiative, 2010; National Council of Teachers of Mathematics, 2000). Understanding the verbal counting system plays an important role in the development of more complex mathematical concepts, and children with higher verbal counting competence are better able to compare quantities (Mix, Huttenlocher, & Levine, 1996). Children’s understanding of numbers (i.e., counting, cardinality, and one-to-one correspondence) is the first step toward being able to appreciate ordinal relationships (Brannon & Van de Walle, 2001).

Thus, by school entry, many children have acquired some mathematical knowledge (Ginsburg et al., 2003; Sarama & Clements, 2009b) that establishes a foundation for learning a more formal mathematics curriculum (Aubrey, 1993). The question is how and where did children develop this elementary knowledge and do they demonstrate evidence of this knowledge during informal contexts? Bryant and Nuñes (2014) argue that there are three possible sources of children’s mathematical knowledge development: (i) children’s logical development (e.g., additive and multiplicative reasoning), (ii) learning about mathematics during meaningful and relevant experiences, and (iii) informal or formal teaching of conventional systems (e.g., counting). We focus on the latter two sources. Most research has employed experimental, lab-based paradigms to assess mathematical knowledge (e.g., Aubrey, 1993), but Tudge and Doucet (2004) argue that it is important to examine how mathematics naturally occurs during everyday activities. Understanding the contexts where children acquire the foundations for later school mathematics has important implications for preschool and primary education and contributes to the literature on the socio-cultural aspects of mathematical development.

The Role of Materials, Context, and Relationships in Children’s Mathematical Experiences

Children’s mathematical knowledge may derive from experiences that are framed by three interrelated factors: (i) available materials, (ii) context, and (iii) social relationships. We review each factor in turn.

Role of materials

Young children may learn mathematical concepts during play with a variety of materials and manipulatives (Canadian Child Care Federation & Canadian Language and Literacy Research Network, 2010; Sarama & Clements, 2009a; Uttal, 2003; Vandermaas-Peeler, Boomgarden, Finn, & Pittard, 2012). For example, while playing with puzzles, youngsters can learn matching and problem solving strategies, one-to-one correspondence, transformations (e.g., flips and turns), and spatial reasoning (Eisenhauer & Feikes, 2009). Blocks and manipulatives (e.g., stacking toys) are fundamental for facilitating pre-mathematical skills such as organization, sorting, measurement, and spatial relations (Ginsburg et al., 2003; Piccolo & Test,
2010). Sarama and Clements (2009a) posited that pretend play may facilitate abstract thinking that is critical for learning algebra. Games with rules include number cards or dice that require players to think about numbers, strategies, and the relations of objects on a game board (Ramani & Siegler, 2008) and thus ‘encourage children to invent and test multiple strategies, to communicate, to negotiate rules and meanings, to cooperate and to reason’ (Sarama & Clements, 2009a, p. 326). In sum, investigating associations between types of materials and siblings’ teaching of specific mathematical concepts will illuminate if particular materials are more prominent in facilitating the instruction of specific concepts and thus may provide practical advice for parents and educators.

**Role of context**

There is a lack of consensus regarding the frequency of children’s involvement in mathematics-related talk and activities during free play in educational settings (Tudge, Li, & Stanley, 2008). On the one hand, Seo and Ginsburg (2004) reported that during free play observations, 88% of 4- and 5-year-olds spontaneously engaged in at least one mathematical activity that included (from most to least frequent) pattern and shape, enumeration, spatial relations, and classification concepts; Ginsburg et al. (2003) reported similar findings for Chinese and American children’s talk during preschool free play periods. On the other hand, Tudge and Doucet (2004) observed preschoolers over the course of a week in a number of contexts (e.g., home, preschool, and park), and 60% never or rarely engaged in explicit mathematical activities. Tudge and Doucet (2004) argue that these contradictory findings may be due to methodological differences (e.g., semi-structured tasks and observations). To our knowledge, a detailed examination of ongoing family interactions at home as a context for siblings’ teaching of mathematics has not been conducted.

**Role of relationships**

The role of relationships in promoting children’s mathematical understanding has received both theoretical and empirical attention. Piaget (1952) argued that children’s mathematical understanding emanated from their interactions with the physical world and sometimes during peer interactions. Vygotsky (1978) also advocated that children learn about mathematical concepts through their interactions with more competent others (e.g., family members and older children) prior to school entry. Following from these perspectives, researchers have examined the parent–child relationship as a significant context facilitating mathematical experiences and knowledge. Based on both self-reports and observations, mothers and children engage in everyday life mathematics-related interactions including invented activities (e.g., reading numbers on licence plates), discussions about food quantities while cooking, and the value of coins while shopping (Aubrey et al., 2003; Blevins-Knabe & Musun-Miller, 1996; Saxe, Guberman, & Gearhart, 1987; Vandermaas-Peeler et al., 2012). While Tudge and Doucet (2004) reported that some children engaged in mathematics-related activities and talk during everyday situations at home, they did not indicate how often these activities occurred with other children or adults. Given the patterns of family interaction reported in these studies and also recent literature indicating that young siblings frequently teach one another during ongoing interactions at home (Howe et al., 2015), it may be that the sibling relationship is one context for the development of children’s mathematical knowledge.
The Present Study

By the time children enter school, they have already become familiar with certain mathematical concepts (e.g., Ginsburg et al., 2003; Sarama & Clements, 2009b). While interactions with parents may be one source of this knowledge (e.g., Aubrey et al., 2003), siblings spend a great amount of time playing together with a wide variety of toys and materials, which may require references to mathematical knowledge (e.g., Sarama & Clements, 2009b; Uttal, 2003). Thus, the sibling relationship may be one important context for the development of mathematical understanding. In fact, given the role of relationships and the physical world (e.g., toys) in facilitating children’s mathematical understanding in the theoretical literature (Piaget, 1952; Vygotsky, 1978), siblings may be well placed to teach one another during informal interactions. Although there is evidence that siblings can teach one another during semi-structured tasks (e.g., constructing puzzles) after adult instruction (e.g., Howe et al., 2006), to our knowledge, this is the first study to investigate how siblings teach one another early mathematical knowledge during ongoing informal, naturalistic interactions at home that do not involve adults. Thus, our study illuminates siblings’ knowledge about mathematics in contexts that are highly relevant and meaningful to children.

We investigated the incidence of naturalistic sibling-directed teaching regarding mathematics over a 2-year period in early childhood, which allowed for an examination of the development of children’s teaching and understanding of mathematical topics over a critical period of early childhood. Siblings were observed in the home setting during naturalistic interactions and conversations with family members at two time points (T1: aged 2 and 4 years; T2: aged 4 and 6 years) for six 90-min sessions at each time. Sequences of intentional sibling-directed teaching by both older and younger siblings were identified on session transcripts (Howe et al., 2015). Following a preliminary content analysis of the process of sibling teaching, mathematical sequences were identified and coded for topics (e.g., numbers), context (e.g., playing with toys), and type of knowledge (i.e., conceptual and procedural).

Children were predicted to engage in more mathematical teaching at T2 than T1 because of their greater cognitive sophistication, knowledge, and experience (Clements, 2004; Cross et al., 2009; Ginsburg et al., 2006). Regarding topics, we expected that siblings would engage in teaching numbers, geometry, and measurement more than other topics (e.g., operations) at both T1 and T2 since these three concepts appear early in young children’s mathematical development (Cross et al., 2009; Sarama & Clements, 2009b). However, by T2, we expected that there would be preliminary evidence of the teaching of operations, relations, and grouping (Brannon & Van de Walle, 2001; Lefevre et al., 2006) given that children would have encountered these concepts as part of their kindergarten and grade 1 curriculum (e.g., Common Core State Standards Initiative, 2010; National Council of Teachers of Mathematics, 2000) and would also have likely addressed them at home.

Regarding contexts, children were predicted to teach mathematical topics during play with different materials (e.g., blocks) or games with rules (e.g., Go Fish!) more than during pretend play (Ginsburg, 2006; Ginsburg et al., 2006; LeFevre et al., 2009; Ramani & Siegler, 2008; Sarama & Clements, 2009a). Given that children on the cusp of middle childhood (ages 6–7 years) are more likely to play games with rules than younger children (Piaget, 1951; Rubin et al., 1983), we predicted this context to be more prominent at T2 than T1. We also hypothesized that everyday informal non-play activities (e.g., cooking) would be a context for
facilitating early mathematical knowledge, based on evidence of activities with parents (Aubrey et al., 2003; Blevins-Knabe & Musun-Miller, 1996; Saxe et al., 1987; Vandermaas-Peeler et al., 2012). Since the literature provides little guidance for hypothesizing which specific mathematical concepts might be taught during everyday contexts, we explored this question. Finally, given that much of mathematical knowledge relies on understanding a variety of concepts (e.g., cardinality and one-to-one correspondence; Brannon & Van de Walle, 2001) and further that sibling teachers focused on conceptual rather than procedural knowledge during informal home interactions (Howe et al., 2015), we predicted that sibling teachers would be most likely to teach conceptual rather than procedural knowledge.

METHOD

Participants

Participants included 39 Caucasian, Canadian, middle-class, two-parent, and two-sibling families, from a mid-sized city in southwestern Ontario, who were representative of the local community. The gender of older and younger siblings was balanced with an equal number of brother–sister dyadic combinations. At time 1 (T1), older siblings’ mean age was 4.4 years ($SD = .31$ years), and younger siblings’ mean age was 2.4 years ($SD = .13$ years); at T2, older siblings’ mean age was 6.3 years ($SD = .42$ years), and younger siblings’ mean age was 4.4 years ($SD = .21$ years). At T1, parents’ ages ranged from 23 to 48 years, and 29% had a university degree, 15% a community college degree, 41% a high school diploma, and 15% had no diploma.

Procedure

In-home observations

Thirty-nine families were observed in their homes for six 90-min sessions at T1 and six 90-min sessions at T2, for a total of 540 min per family at each time point; at both T1 and T2, some families were observed for an additional session, because some of their sessions had been cut short for various reasons, but the data were pro-rated to equal 540 min at each time point (Ross, Filyer, Lollis, Perlman, & Martin, 1994; Ross, Martin, Perlman, Smith, Blackmore, & Hunter, 1996). Observers remained inconspicuous, and families were asked not to use electronic devices but to engage in normal everyday interactions and to ignore the observer. A tape recorder registered all speech on one track during the live observations, while at the same time, observers dictated behavioural codes (i.e., 96 behaviours such as laugh, smile, hit, grab, show, request an action, and disagree verbally) and descriptions of sibling and parent verbal and physical interaction onto a second track of the recorder. The sessions were transcribed for sibling and parent interaction and language. In the present study, these transcripts provided a rich and unique data source for identifying naturalistic sibling-directed teaching sequences; the behavioural codes provided a clear indication of the sibling interaction and were used as a guide or evidence of possible teaching.

Transcription reliability of original observations (Ross et al., 1994, 1996)

Seventeen 20-min sessions at T1 and ten 20-min sessions at T2 were transcribed to determine interrater reliability on the transcripts (Ross et al., 1994, 1996); the
transcribed sessions were then assessed for percent of agreement for the presence of each coded behavioural action (e.g., give and grab; T1 = 92%, range = 79–100%; T2 = 86%, range = 70–100%) and sequences of interaction (e.g., conflict and play; T1 = 99%, range = 86–100%; T2 = 95%, range = 86–100%).

Identification of sibling teaching sequences

The present study was part of a larger project examining sibling-directed teaching during naturalistic home observations (Howe et al., 2015); 1,413 intentional sibling-directed teaching sequences were identified across both time points in 38/39 sibling dyads (one dyad did not engage in teaching). At T1, 374 teaching sequences were identified (1–66 turns per sequence, M = 4 turns), and at T2, 1,039 teaching sequences were identified (2–114 turns per sequence, M = 20.44 turns). Teaching sequences were identified on the transcripts based on the clear and obvious intention of one sibling to teach the other so as to ‘cause learning in someone else’ (Strauss & Ziv, 2012, p. 188). Identified sequences began with explicit references by either older or younger sibling indicating his/her intention to teach (this child was identified as the teacher; e.g., ‘I’ll show you how…’) or one sibling directly requesting teaching (i.e., identified as the learner; e.g., ‘Why does 4 come after 3?’) from the other child who then provided instruction (who was labelled the teacher). The 1,413 teaching sequences included explicit and direct statements to teach (e.g., ‘I’m going to teach you numbers’), indirect sharing of information (e.g., ‘remember what I said, in which slot does the 25 cents go in the coin bank?’), a request for teaching (e.g., ‘why are you taller than me?’), or corrections (e.g., ‘that’s the wrong end. This end is the bigger one’). The start of each sequence began when teaching commenced and terminated when the teaching ended or the topic changed. To be conservative, conversations that may have included implicit learning or when parents joined the sibling-directed teaching (as guides or teachers) were not coded. Each sequence was also coded for the teaching of conceptual (e.g., concepts and labels) or procedural knowledge (e.g., how to do something; Howe et al., 2015; Hatano & Inagaki, 1986; see Table 1); these codes were mutually exclusive.

Interrater reliability for the identification of the teaching sequences on 21% of the transcripts was established by two naïve but trained research assistants (Howe et al., 2015). Reliability was determined by calculating coders’ agreements or disagreements about whether each line was part of a teaching sequence (kappa = .78, p < .001). Agreements were counted when both coders identified the same line in a sequence; if only one coder identified a line, this was counted as a disagreement. If one coder failed to identify an entire sequence, each line was counted as a disagreement. These coders also established interrater reliability for the teaching of conceptual or procedural knowledge (kappa = .74, p < .001).

Coding of Mathematics Teaching Sequences

After identifying the 1,413 teaching sequences, we then reviewed each one to determine which sequences involved the teaching of mathematics. Based on the literature, we developed a coding scheme to categorize the topics and context of mathematics teaching (e.g., Ginsburg, 2006; Sarama & Clements, 2009b; Seo & Ginsburg, 2004). Mathematical topics were coded for (i) number, (ii) operations, (iii) relations, (iv) grouping, (v) geometry, and (vi) measurement (see Table 1 for...
Table 1. Definitions and examples of mathematics topics, contexts, and knowledge types

<table>
<thead>
<tr>
<th>Mathematical Topics</th>
<th>Definition</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numbers</td>
<td>Counting numbers and describing how many items in collections, including the counting principle, cardinality, number word list, one-to-one correspondence, and written number symbols.</td>
<td>'I have 1, 2, 3, 4, 5, 6, 7...(counting the number of cards)';</td>
</tr>
<tr>
<td></td>
<td></td>
<td>'You need ten Kevin'.</td>
</tr>
<tr>
<td>Operations</td>
<td>Composition and decomposition of numbers, including addition, subtraction, multiplication or grouping of numbers, division or partitioning, and equal partitioning.</td>
<td>'What’s five plus five?';</td>
</tr>
<tr>
<td></td>
<td></td>
<td>'Three plus three equals six'.</td>
</tr>
<tr>
<td>Relations</td>
<td>Referring to ‘more than’, ‘less than’, and ‘equal to’.</td>
<td>'Whoever has the most money at the end wins; that’s the highest'.</td>
</tr>
<tr>
<td>Grouping/Classification</td>
<td>Arrangement of groups according to an established criterion.</td>
<td>'Keep them in a pile, like blue with blue and red with red'.</td>
</tr>
<tr>
<td>Geometry</td>
<td>Study of shapes and space, spatial transformation, and symmetry (move and change shapes), including the overall shape, building, naming and describing blocks, references to relative location (above and below), pattern recognition, use of coordinates to name and find locations, slide, and flip and turn 2-D shapes.</td>
<td>'That’s a triangle; you can put them beside the other ones (referring to blocks)'; 'You can’t go backwards'.</td>
</tr>
<tr>
<td>Measurement</td>
<td>Determining object’s size and indicating how much of something. Connecting number and geometry realms (size, length, area, weight, and volume), quantifying other attributes, comparing length and density, and measurement techniques.</td>
<td>'I only weigh four'; 'I’ll show you how much money you have'.</td>
</tr>
<tr>
<td>Contexts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Playing with materials/toys</td>
<td>Materials/toys that have no prescribed or specific way to use them and can be used in many different ways (open-ended).</td>
<td>Lego, art materials, playdoh, dolls or figurines, and spirograph</td>
</tr>
<tr>
<td>Playing games-with-rules</td>
<td>Playing games that require specific pre-defined rules.</td>
<td>Board games or sports (e.g., checkers)</td>
</tr>
<tr>
<td>Pretend play</td>
<td>Engaging in pretence with or without the use of materials.</td>
<td>Pretending to be a duck</td>
</tr>
<tr>
<td>Everyday interactions</td>
<td>Non-play activities that occur in everyday life.</td>
<td>Cleaning up, eating, and cooking</td>
</tr>
<tr>
<td>Other</td>
<td>Activities that do not involve or do not fall under the other categories.</td>
<td>Conflict</td>
</tr>
<tr>
<td>Knowledge Types</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conceptual</td>
<td>Talk about concepts, labels, and general knowledge.</td>
<td>Difference between a square and circle and name of shape (e.g., triangle)</td>
</tr>
<tr>
<td>Procedural</td>
<td>Talk about how to do something.</td>
<td>How to write the number 10 and how to trace and connect dots</td>
</tr>
</tbody>
</table>

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definitions and examples). The topics were mutually exclusive, but more than one topic could be coded in a given sequence. Each mathematical sequence was coded (mutually exclusive codes) once for context: (i) playing with materials/toys, (ii) games with rules, (iii) pretend play, (iv) everyday interactions, and (v) other (see Table 1).

Reliability of mathematics teaching

In the present study, two new, naïve assistants conducted the mathematics coding reliability. First, we identified which of the original 1,413 teaching sequences included mathematics teaching; all sequences were reviewed, and it was determined that 405/1,413 referred to mathematics (coders’ agreement on 31% of randomly selected sequences = 80%). Next, 21% of the mathematical sequences were randomly chosen for reliability coding of topics and contexts; kappas (all \( p < .001 \)) were number (.86), operations (.66), relations (.78), grouping (.72), geometry (.66), measurement (.76), and contexts (.85).

RESULTS

Results focus on the topics of mathematical teaching, developmental differences in teaching over a 2-year period, contexts, and types of knowledge taught. Frequencies of teaching sequences by topic, context, and type of knowledge at T1 and T2 were compiled and reported as percentages in the descriptive findings section. Some sibling dyads engaged in teaching more frequently than others. Thus, to ensure that the data from each dyad were weighted equally, dyad (not sequence) was treated as the unit of analysis; proportion scores were then calculated to control for the number of sequences per family. For example, to calculate the proportion of games with rules sequences that focused on the topic of number, the variable of number was calculated by dividing by all games with rules teaching sequences for that family. Mean proportion scores were used as the dependent measures in a series of factorial analyses of variance (ANOVAs) that included mathematical topic, context, type of knowledge, and time (T1 and T2) as repeated measures factors to test for differences in sibling teaching across the two time points.

Descriptive Findings

Across both time points, older siblings taught 80.2% of the time (\( n = 325 \) sequences), while younger siblings taught 19.8% of the time (\( n = 80 \)). A repeated measures ANOVA comparing older and younger siblings’ teaching of mathematical topics revealed only a main effect of topic, \( F(2, 26) = 16.44, p < .001 \), and no interaction between sibling and mathematical topic, \( F(2, 26) = 2.12, p = .14 \). Further, a repeated measures ANOVA comparing older and younger siblings’ teaching by context revealed only a main effect of context, \( F(2.29, 1.04) = 4.75, p < .01 \) (degrees of freedom corrected using Greenhouse–Geisser estimates due to violation of sphericity, \( \varepsilon = .16 \)), and no interaction between sibling and the context of the mathematical teaching, \( F(3, 24) = 1.61, p = .21 \). Given that there were no significant differences in the mathematical teaching of older versus younger siblings, the data for older and younger sibling teachers were combined in all subsequent analyses.
Context for teaching

The teaching of mathematical topics occurred in several different contexts (see Table 2). Across T1 and T2, playing with materials/toys was the most frequent context (39%), followed by playing games with rules (31%), everyday interactions (17%), pretend play (9%), and other (4%). The category of other was dropped due to its low frequency.

Mathematical topics

Across the two time points (see Figure 1), the topic of numbers was taught most often (n = 191; 37.5%), followed by geometry (n = 190; 37.3%), measurement (n = 70; 13.7%), relations (n = 23; 4.5%), grouping (n = 21; 4.1%), and operations (n = 15; 2.9%). In the majority of sequences (n = 315; 77.8%), only one topic per sequence was identified; in 19.0% of sequences (n = 77), two topics were coded, in 2.7% (n = 11) of sequences, three topics were coded, and in two cases (0.5%), four topics were identified. As predicted, three mathematical topics (i.e., number, geometry, and measurement) were taught most frequently (number by 37/38 dyads, geometry by 36/38 dyads, and measurement by 26/38 dyads) and thus became the focus of subsequent analyses. The teaching of grouping, relations, and operations occurred infrequently, which did not permit a refined analysis of these topics.

Table 2. Frequency of each context of teaching at time 1 and time 2

<table>
<thead>
<tr>
<th>Context</th>
<th>T1</th>
<th>T2</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Playing with materials/toys</td>
<td>38</td>
<td>119</td>
<td>157</td>
</tr>
<tr>
<td>Playing games with rules</td>
<td>5</td>
<td>120</td>
<td>125</td>
</tr>
<tr>
<td>Everyday interactions</td>
<td>10</td>
<td>59</td>
<td>69</td>
</tr>
<tr>
<td>Pretend play</td>
<td>5</td>
<td>32</td>
<td>37</td>
</tr>
<tr>
<td>Other</td>
<td>3</td>
<td>14</td>
<td>17</td>
</tr>
<tr>
<td>Total</td>
<td>61</td>
<td>344</td>
<td>405</td>
</tr>
</tbody>
</table>

Figure 1. Frequency of mathematical topics taught at time 1 (T1) and time 2 (T2).
Teaching of conceptual and procedural knowledge

To test our prediction that children would teach conceptual mathematical knowledge more frequently than procedural knowledge, a one-sample t-test was conducted comparing both types of knowledge (test value = .50); this approach accounted for chance given the mutually exclusive codes (proportionalized to equal 1.0). As expected, the teaching of mathematical topics was more likely to involve conceptual ($M = .70, SD = .16$) than procedural knowledge ($M = .30, SD = .16$), $t(38) = 7.98, p < .001$.

Mathematical Teaching Over Time

Mathematical teaching

At T1, 61/374 (16.3%) teaching sequences involved mathematics, and at T2, 344/1039 teaching sequences (33.1%) involved mathematics for a total of 405/1413 of the teaching sequences (28.7%). A paired-samples t-test was conducted to compare the proportion of mathematics teaching sequences out of the total number of teaching sequences for each family at T1 and at T2. As expected, there was a significant difference between the proportion of mathematics teaching at T1 ($M = .15, SD = .21$) and at T2 ($M = .30, SD = .28$); $t(38) = -2.77, p = .009$; a higher proportion of teaching sequences involved mathematics at T2 compared to T1.

Mathematical topic and time

To test the hypothesis that certain topics (e.g., operations) would be more frequent at T2, a 3 (topic) × 2 (time) repeated measures ANOVA was conducted. It revealed a significant main effect for topic, $F(2, 60) = 13.17, p < .001$, but no interaction between topic and time (see Table 3). Post hoc pairwise comparisons adjusted using Bonferroni corrections indicated that numbers and geometry were taught more than measurement at both time points (at T1, $p = .027$ and .010, respectively; at T2, both $p$s = .001).

Table 3. Proportions of mathematical topics and context of teaching by time 1 and time 2

<table>
<thead>
<tr>
<th>Mathematical topic</th>
<th>T1</th>
<th>T2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numbers</td>
<td>.42(^a)</td>
<td>.43(^c)</td>
</tr>
<tr>
<td>Geometry</td>
<td>.45(^b)</td>
<td>.40(^c)</td>
</tr>
<tr>
<td>Measurement</td>
<td>.12(^ab)</td>
<td>.17(^c)</td>
</tr>
<tr>
<td>Context of teaching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Playing with materials/toys</td>
<td>.59(^bc)</td>
<td>.36(^a)</td>
</tr>
<tr>
<td>Playing games with rules</td>
<td>.07(^cd)</td>
<td>.32(^d)</td>
</tr>
<tr>
<td>Pretend play</td>
<td>.10(^b)</td>
<td>.12(^a)</td>
</tr>
<tr>
<td>Everyday interactions</td>
<td>.25</td>
<td>.20</td>
</tr>
</tbody>
</table>

\(^a\)Significantly different within T1 and within T2 ($p < .05$).
\(^b\)Significantly different within T1 and within T2 ($p < .01$).
\(^c\)Significantly different within T2 and within T2 ($p < .001$)
\(^d\)Significantly different across T1 and T2 ($p < .001$)
Context of teaching and time

To test the hypotheses that (i) overall children would teach mathematical topics more during play with concrete materials than other contexts and (ii) games with rules would be more prominent at T2 than T1, a 4 (contexts) × 2 (time) repeated measures ANOVA was conducted (see Table 3). Mauchly’s test indicated that the assumption of sphericity was violated for the interaction of context and time, \( \chi^2(5) = 22.74, p < .001 \); thus, the degrees of freedom were corrected using Greenhouse–Geisser estimates of sphericity (\( \varepsilon = .66 \)). A main effect of context was revealed, \( F(3, 84) = 10.04, p < .001 \); mathematics teaching occurred more while playing with materials/toys than games with rules, or pretend play, thus supporting the overall hypothesis. This effect was qualified by an interaction between the context of mathematics teaching and time, \( F(1.97, 55.09) = 4.10, p < .05 \). Simple effects analyses indicated a trend (\( p = .056 \)) for mathematics teaching to occur more often while playing with materials/toys at T1 than at T2; however, as expected, mathematics teaching occurred proportionately more often in the context of games with rules at T2 than at T1.

Relations between Mathematical Topic, Context, and Type of Knowledge

Mathematical topic and context

To make a comparison between the contexts in which mathematical topics were taught, proportion scores were calculated. For example, total instances where the teaching of numbers occurred while playing with materials and toys were divided by the teaching of numbers in all four contexts. A 3 (topic) × 4 (context) repeated measures ANOVA revealed a main effect of context, \( F(3, 72) = 6.99, p < .001 \), qualified by a significant interaction, \( F(6, 144) = 3.98, p < .01 \), between topic and teaching context. Simple effects analyses indicated that in the context of games with rules, the teaching of both number (\( M = .36, SE = .06 \)) and geometry (\( M = .30, SE = .06 \)) was more likely to occur than measurement (\( M = .08, SE = .05 \); \( p = .006 \) and \( .002 \), respectively). In contrast, numbers, geometry, and measurement were equally likely to be taught in the contexts of playing with materials and toys (\( M = .37, SE = .06 \); \( M = .48, SE = .06 \); \( M = .45, SE = .08 \), respectively), pretend play (\( M = .07, SE = .03 \); \( M = .05, SE = .03 \); \( M = .19, SE = .07 \), respectively), and everyday interactions (\( M = .20, SE = .05 \); \( M = .17, SE = .04 \); \( M = .28, SE = .07 \), respectively).

Mathematical topic and type of knowledge

To test the prediction that children would engage in teaching more conceptual than procedural knowledge within each topic, proportion scores were calculated, for instance, by dividing the total occurrences in which numbers were taught in a conceptual fashion by all occurrences in which the three mathematical concepts were taught in a conceptual fashion. A 2 (knowledge) × 3 (topic) repeated measures ANOVA revealed a main effect of topic qualified by an interaction, \( F(2, 64) = 12.38, p < .001 \), between the type of knowledge and topic. Simple effects analyses showed that children were more likely to focus on conceptual (\( M = .44, SE = .04 \)) rather than procedural knowledge (\( M = .30, SE = .04 \); \( p < .01 \)) when teaching number. In contrast, children were more likely to teach geometry using procedural (\( M = .60, SE = .05 \)) as opposed to a conceptual knowledge (\( M = .39, SE = .03 \); \( p < .001 \)). No significant difference was revealed between the teaching of conceptual (\( M = .17, SE = .03 \)) and procedural (\( M = .10, SE = .04 \)) knowledge for instruction about measurement.
**Type of knowledge and context**

To assess differences between type of knowledge and the context in which mathematical topics were taught, proportion scores were calculated by, for example, dividing all cases in which mathematical topics were taught in a conceptual fashion in the context of games with rules by all cases in which mathematical topics were taught in both fashions during games with rules. Following this, a 2(knowledge) × 4(context) repeated measures ANOVA was conducted. Mauchly’s test indicated that the assumption of sphericity was violated for the main effect of context, \( \chi^2(5) = 13.97, p < .05 \); thus, the degrees of freedom were corrected using Greenhouse–Geisser estimates of sphericity (\( \epsilon = .66 \)). Findings indicated a main effect of context, \( F(1.99, 41.77) = 6.09, p < .01 \), qualified by an interaction between the type of knowledge and context of teaching, \( F(3, 63) = 3.02, p < .05 \). Simple effects analyses indicated that when mathematical topics were taught during games with rules, teachers focused on conceptual (\( M = .29, SE = .07 \)) rather than a procedural knowledge (\( M = .06, SE = .05 \); \( p < .05 \)). A trend (\( p = .08 \)) was revealed between the type of knowledge and the context of materials/toys (\( M = .38, SE = .07 \); \( M = .57, SE = .10 \); conceptual and procedural, respectively), but no significant differences were apparent for pretend play (\( M = .09, SE = .03 \); \( M = .19, SE = .08 \), respectively) or everyday interactions (\( M = .25, SE = .06 \); \( M = .18, SE = .08 \), respectively).

**DISCUSSION**

We investigated sibling-directed teaching of mathematical concepts during informal naturalistic home interactions by addressing the frequency of mathematics teaching, topics, contexts, and types of knowledge, as well as change over time in dyadic interaction.

**Sibling Teaching of Mathematics: Frequency and Topics**

It was striking that 30% of the originally identified sibling teaching sequences in the Howe et al. (2015) study involved mathematical concepts. It appears that both older and younger siblings engage in teaching and learning about mathematical concepts during ongoing and meaningful exchanges as they act as socialization agents for one another (Howe et al., 2011).

**Topics**

All but one sibling dyad engaged in teaching, and nearly all taught three mathematical concepts (number, geometry, and measurement) at both time points; there was early evidence of the teaching of relations, grouping, and operations at T2. These findings are in line with the literature indicating that young children mostly reason about number, geometry, and measurement concepts (Clements, 2004; Cross et al., 2009; Sarama & Clements, 2009b). Perhaps as children begin to acquire an early understanding of these concepts, they also are motivated to teach their sibling during play interactions in early childhood (Dunn, 2002; Howe et al., 2011). The availability of a wide range of toys, games, and play materials in their homes may sometimes have afforded a context for teaching. It is also possible that siblings’ interactions with these play materials elicited the need to use and teach mathematics to one another; we know that children can adjust their
conversation style based on their interlocutor (Shatz & Gelman, 1973); thus, the content of their conversations may also be influenced by the context. Although we were not able to determine how much actual learning occurred nor the accuracy of the information being taught, the critical point of our study is that siblings engaged in teaching one another mathematical concepts during their ongoing daily and meaningful interactions. We speculate that this may be one way that siblings may co-construct a shared understanding of their physical and cognitive worlds.

The teaching of number occurred most frequently, as illustrated by one sibling who instructed, ‘Infinity means it goes on forever’, or another who taught, ‘Do you want a couple? That means two’. These examples demonstrate that children have the ability to reflect on how numerical systems operate (Ginsburg et al., 2002; Sarama & Clements, 2009b) and can at least begin to define these meanings for one another, which is a critical skill for later mathematics functioning (Jordan, Kaplan, Ramineni, & Locuniak, 2009). Geometry concepts were taught almost as frequently as number and many examples involved shapes and transformations in space (e.g., ‘that’s a circle, I’m gonna color all the things that are circles’ and ‘those are side down and those are side up’). Measurement was the third most frequent concept taught (e.g., ‘there’s a big end and a small end’) but occurred less frequently than number and geometry. The examples included attributes of objects (e.g., height and weight). As one child said, ‘I only weigh four’, which the older sister corrected by saying ‘forty’, which indicates that her spontaneous instruction was based on at least an elementary understanding of measurement. As Cross et al. (2009) argue, both geometry and measurement are practical and powerful systems for understanding, describing, and representing the world. Our findings suggest that young siblings are interested in sharing knowledge with one another about how these abstract systems operate during ongoing sibling interactions, which were not prompted by adult intervention, thus supporting the argument that teaching is a natural cognitive activity for children (Strauss & Ziv, 2012; Strauss, Ziv, & Stein, 2002).

Teaching over time

Siblings engaged in more mathematics teaching at T2 than at T1, thus supporting our hypothesis. This finding was expected given the more sophisticated cognitive skills of both children and their longer history of shared experiences by T2. Interestingly, the teaching of number and geometry was more frequent than measurement at both time points. Siblings’ teaching of grouping (e.g., ‘Keep them in a pile. Like blue with blue and red with red, ok?’), operations (e.g., ‘3 plus 3 equals 6’), and relations concepts (e.g., ‘No, 6 is bigger than 4’) was mostly first observed at T2. Although the frequency of teaching of these three concepts was low compared to number, geometry, and measurement, it suggests that the children were beginning to develop some preliminary knowledge of the more sophisticated concepts. In fact, Butterworth (2005) argues that numerosity (i.e., knowledge of the number of items in a set) is a precursor to understanding the relations between numbers and arithmetic (i.e., operations). We speculate that some of the more sophisticated mathematical concepts may have been facilitated by children’s involvement in games with rules, which become more prominent in their play on the cusp of middle childhood (Piaget, 1951; Rubin et al., 1983). In addition, the teaching of grouping, operations, and relations concepts may have been partly influenced by older siblings’ school
experiences, who by age 6 would have received more formal mathematics instruction in kindergarten or grade 1 (typically Canadian children enter kindergarten at age 5) (Common Core State Standards Initiative, 2010; National Council of Teachers of Mathematics, 2000).

Contexts and Sibling Teaching of Mathematics

Siblings interact in a wide variety of both positive and more negative contexts during their ongoing exchanges at home (Dunn, 2002; Howe et al., 2011; Volling, 2003). As expected, some contexts were more prominently associated with sibling teaching of mathematical concepts, specifically during play with materials/toys compared to games with rules, pretend play, and everyday interactions. These findings are generally in line with our hypothesis and support literature indicating that materials/toys such as manipulatives (e.g., construction toys and blocks) may be critical in facilitating children’s early mathematical knowledge (Ginsburg et al., 2002; Eisenhauer & Feikes, 2009; Piccolo & Test, 2010). As Ginsburg et al. (2003) argue, these concrete play materials facilitate the development of early mathematical skills such as sorting, organizing, matching, understanding spatial relations, and measurement. For example, as children use blocks to construct roads and buildings, the need to sort the blocks by shape or to line up the same number of blocks to construct a sturdy building will naturally be embedded into their interactions so as to ensure successful construction (Leeb-Lundberg, 1996). Trial and error strategies also occur during construction and may perhaps enhance and test children’s mathematical knowledge, a speculation requiring further study.

The context of games with rules was associated with opportunities to develop specific mathematical concepts, namely number and geometry concepts more than measurement, while the materials/toys, pretend play, and the everyday contexts were not associated with teaching particular topics. Although Sarama and Clements (2009a) argued that symbolic (pretend) play may be important for facilitating children’s abstract thinking critical for learning algebra concepts, we did not find an association; perhaps longitudinal research might illuminate an association between engaging in pretence and later more abstract mathematical concepts evident in school-aged children. Finally, based on literature indicating that mothers discuss and teach mathematical concepts during everyday interactions (e.g., Aubrey et al., 2003; Blevins-Knabe & Musun-Miller, 1996), we had expected a similar association for siblings, but our hypothesis was not supported. Perhaps such activities occur more frequently with parents than siblings.

Interestingly, mathematics teaching was more likely to occur during play with materials/toys at T1 than at T2, whereas it was observed significantly more frequently during games with rules at T2 than at T1. Although both contexts increased in raw frequencies over time, the materials/toys context constituted 11% of the teaching sequences at both time points, whereas games with rules increased from 1% to 11% of sequences over time. Developmental differences in children’s play patterns may be evident here. That is, the more concrete nature of play materials/toys such as manipulatives and blocks may be more appealing and developmentally appropriate for younger children (ages 2 and 4 years), whereas games with rules become integrated into children’s play as they approach the concrete operational period (ages 5–6 years) and can handle more abstract ideas (Piaget, 1951; Rubin et al., 1983). Games with rules often employ dice or number
cards that require children to note the relations of objects on a board or the numbers on cards so as to consider strategies to win and are considered a critical component of early number knowledge (Ramani & Siegler, 2008; Siegler & Ramani, 2009). Thus, understanding basic number and relations concepts is required to play a game successfully with others (Sarama & Clements, 2009a), and this becomes an increasingly important context for teaching mathematics as children mature over the preschool period.

In sum, prior to school entry, children clearly encounter mathematics in their informal but meaningful play activities with their siblings, thus helping to lay the foundation for formal school-based mathematics instruction. In fact, given that children’s play is often characterized by spontaneous self-initiated activities or games that involve numbers (Saxe et al., 1987) and siblings are frequent play partners (Dunn, 2002; Howe et al., 2011), it is not surprising that the sibling relationship is a rich context for teaching mathematical concepts.

**Teaching of Conceptual and Procedural Knowledge**

Finally, we addressed the issue of whether siblings focused on teaching conceptual or procedural knowledge while teaching mathematical concepts. Children were more likely to focus on conceptual knowledge when teaching number (e.g., younger sibling said: ‘I ate one [Smartie]’, older sibling replied: ‘That makes six still. Six. Used to be seven, now it’s six.’), whereas they focused on procedural knowledge when teaching geometry (e.g., [The older sibling is teaching how to write the letter N] ‘Oh, stop here and then go up, then go down. That’s how you do Ns. It just has to be straight’.). No differences were evident for teaching measurement. This pattern of findings was also qualified by the teaching context; when teaching occurred with materials/toys, a trend indicated that procedural knowledge was more likely to be taught. The concrete nature of materials/toys may have facilitated a focus on procedural ‘how to’ knowledge rather than conceptual knowledge, which presumably requires more abstract thinking. In contrast, during games with rules, siblings were significantly more likely to refer to conceptual knowledge, which may reflect their more sophisticated cognitive skills (e.g., ‘The highest amount of money is this [holds up a game piece]. This is the highest, the golden eggs are second.’); Howe et al. (2015) also reported that older preschoolers taught more conceptual than procedural knowledge.

In a study on the development of young children’s conceptual and procedural knowledge of counting, LeFevre et al. (2006) reported that by grade 2, children had strong procedural counting abilities, whereas their conceptual knowledge was still developing. This might be the case for what children know but does not address the question of what they are interested in teaching. Methodological differences (experimental procedures versus naturalistic observations) might account for the findings of the two studies. Furthermore, research on sibling teaching employing semi-structured teaching paradigms that focus on procedural knowledge may provide a somewhat restricted picture of young children’s abilities (e.g., Azmitia & Hesser, 1993; Howe & Recchia, 2009). Our findings, however, indicate that young children are interested in and provide instruction about concepts that require an understanding of the world and the ability to convey abstract mathematical ideas in contexts that are relevant to them (Bryant & Nufies, 2014). Ginsburg et al. (2006) demonstrated that such intuitive mathematical knowledge evolves from children’s own conceptual understanding during their interactions with the world (i.e., objects, everyday routines, and sharing).
Of course, we cannot determine the direction of effects, but it makes sense that the children would sometimes engage in conceptual teaching.

Limitations, Implications, and Conclusions

Our sample of Caucasian, predominantly middle-class families indicates that future research should include more economically and culturally diverse participants, so as to provide a broader understanding of sibling teaching of mathematics. While our rich naturalistic data provide new insights into sibling teaching, at times the transcripts lacked some detail making it challenging to determine the accuracy and developmental appropriateness of the teaching and learning outcomes. Also, there was no information on the children’s social-cognitive skills or formally assessed mathematical knowledge, which would have addressed other interesting questions.

Parents can help facilitate children’s mathematical understanding by recognizing and affording opportunities for this development and by engaging their children in everyday activities involving mathematical vocabulary, counting, shape recognition, comparison, sequence, matching and grouping, and measuring (Benigno & Ellis, 2004; Saxe et al., 1987). These parental behaviours may provide role models for siblings to emulate when teaching one another. Additionally, parents should provide children with materials to support mathematical development (e.g., blocks and board games) and allow siblings ample time to interact together without adult involvement. Such strategies may be effective in promoting children’s early mathematical knowledge in a context that is meaningful and relevant to young siblings.

In conclusion, to our knowledge, this is the first study to demonstrate young children’s interest and engagement in teaching mathematics to their siblings during naturalistic ongoing interactions in the home setting. As Strauss and Ziv (2012) argue, teaching and learning are natural cognitive abilities. One cannot escape the conclusion that young children are fascinated by mathematics and employ various concepts in their naturalistic and ongoing sibling interactions with great frequency with the clear intention of teaching one another. Clearly, the process of teaching mathematics to one another affords children the opportunity to explore and co-construct an understanding of their social and physical worlds.

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