

Developing Mathematical Concepts in Australian Pre-school Settings: The Background

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The SIMERR project *Mathematical Thinking of Pre-school Children in Rural and Regional Australia: Research and Practice* included a review of relevant research literature with the aim of making this accessible to researchers as well as early childhood teachers and educators. This paper introduces the methods used in the project and provides a brief summary of the literature pertaining to the development of mathematical concepts.

Background

Mathematical Thinking of Pre-school Children in Rural and Regional Australia: Research and Practice, a SiMERR project, involved a team of 12 researchers from Australia and New Zealand. Members of the “Early Years Mathematics Forum” had met over the previous 2 years to discuss issues and share resources related to mathematics in the range of prior-to-school settings—mainly kindergartens, pre-schools, and long day care centres—as well as the preparation of early childhood teachers.

Research into the early childhood development of mathematical concepts, language and skills is important because mathematical development appears to begin in the first few months after birth, a good early childhood start in mathematics is critical in later mathematics success, and pre-cursors to more formal mathematical thought and language can be found in very young children. Hunting et al. (2008) provide examples of research into the development of basic operations and activities that support problem solving strategies, numerical operations, measurement, spatial and geometric reasoning, pattern creation and recognition, as well as logical and probabilistic reasoning. By the time children attempt to blow out their first birthday candles, they have acquired by experiential learning the rudiments of a wide range of mathematical concepts. Many older pre-school children are capable of symbolic and abstract thought far beyond traditional expectations (Ginsburg, Lee, & Boyd, 2008).

Much of a young child’s experience base for quantitative, logical, and spatial knowledge is acquired through social interactions involving play, conversations, and adult-directed activity in prior-to-school childcare settings as well as in their homes. Teachers have marked influence on children’s development (Cuttance, 1998), so it is vital to know what early childhood carers and teachers understand about (a) mathematical concept development, and (b) activities that promote such development. This research captured data on early childhood staff attitudes towards mathematics, background mathematics knowledge, views about learning and teaching of mathematical concepts, experience with technology including computers, and perceptions of resource needs and requirements.

Methods

For the annotated bibliography, research published from 2000 on with a focus on mathematical capacities, foundations and development in children aged 0-5 years was reviewed. The survey and interview stage of the project involved a representative sample

of 64 prior-to-school practitioners from regional and rural New South Wales, Queensland, and Victoria. Surveys were used to collect background data about these practitioners and their settings, and then each was interviewed using a set of structured questions. In some of the venues, video was taken to illustrate aspects of the mathematical thinking and development of young children. The surveys, interview questions, data analysis and sorting, and the report writing were all structured around 5 broad themes: children's mathematics learning, support for mathematics teaching, technology, attitudes and feelings, and assessment and record keeping.

This paper focuses on one portion of the project (the literature review), and one aspect of children's mathematics learning—the development of specific concepts.

Literature about the Development of Mathematical Concepts

Even though mathematical development is obvious in the first few years of life (see, for example the video data discussed by Papic, Mulligan, and Bobis (this volume), there do not seem to be many longitudinal studies that have particularly illuminated the development of mathematical concepts in the first three years of life (Hughes, 1986; Wynn, 2000). There is no shortage of general advice, though: some states and countries have documents that outline early childhood curriculum expectations and many early childhood texts mention toddlers' mathematical concept development. Clements, Sarama, and DiBiase (2004), for example, review the topics, sequences, and learning trajectories that children can and should learn at each of their first years of life, with specific developmental guidelines that suggest appropriate content from 2-year-olds up. There is also research evidence of quantitative development in infants, illustrating impressive quantitative accomplishments that occur during this period as well as the intricate conceptual relations that must be worked out to produce them (Mix, Huttenlocher, & Levine, 2002). As well, the more general research on cognitive development in very young children (Shonkoff & Phillips, 2000) has shown that interactions in high-quality early childhood settings are influential on the development of these children's language and cognitive skills.

There is, however, a rich body of research on the learning of 4-year-old children in kindergartens. In a study of counting, number patterns, magnitude comparisons, estimating and number transformation, Jordan, Kaplan, Locuniak, and Ramineni (2007) found that the development of number concepts in prior-to-school contexts correlated with success in the early years at school. Clements and Sarama (2007) reported that concept development can be enhanced significantly with appropriate play-based programs that use children's experiences and interests. This is particularly important for children in low SES areas, as shown in the *Big Math for Little Kids* program (Greenes, Ginsburg & Balfantz, 2004) and by Starkey, Klein, & Wakely's (2004) pre-kindergarten intervention program. Research reports are rich with examples of materials and activities used successfully to develop children's knowledge of measurement (Copley, Glass, Nix, Faseler, De Jesus, & Tanksley, 2004), spatial representation (Davis & Hyun, 2005), data (Forrest, Schnable, & Williams, 2007), patterning (Highfield & Mulligan, 2007), arithmetical problem solving (Klein & Bisanz, 2000), and notation (Brizuela, 2004), as well as part-whole reasoning and fractioning (Hunting, 2003). Hunting noted that young children were not only able to reason about relationships between small sets of physical items but they also seemed able to make sets of 1-3 in their mind in the absence of materials.

Gifford (2004) explored the nature of and developed a framework for cognitive processes involved in mathematics learning by children aged 3 to 5 and considered three of

these to be most important: generalizing, restructuring and representing. Approaches used to teach such ideas, particularly in relation to cardinal number, were explored by Novakowski (2007) who considered the types of experiences that promote the development of number sense through composition and decomposition of whole numbers.

Other researchers have focused on knowledge children have when they are about to enter school. As found by Clarke, Clarke, and Cheeseman (2006) in task-based, one-to-one interviews with over 1400 young children, they bring high quality, robust mathematical understandings to school and many are more advanced than the curricula. This has consequences because Aubrey, Dahl and Godfrey (2006), who also studied a large number of English children, found that conceptual knowledge in reception year was predictive of later achievement.

Canobi, Reeve, and Pattison (2002) recorded evidence of pre-schoolers' understandings of the composition of numbers, commutativity, and associativity, developed initially in the context of physical objects. There are many everyday materials that can be used by creative teachers at this level. Barnes (2006), for example, wrote about how a calendar was used to develop time concepts as well as number and pattern understandings, noting that the use of such aids needs to be functional and of immediate, meaningful use for the children.

Conclusion

The evidence from the *Mathematical Thinking of Pre-school Children in Rural and Regional Australia: Research and Practice* project is that educators in prior-to-school settings recognise that their children can be quite capable mathematicians. Many of the practices implemented by these educators, while strongly based in a play-centred philosophy, are designed to facilitate children's mathematical learning (Hunting & Pearn, this volume). However, there is still much to do.

While there is a great deal of information available about the mathematical development of 4- to 5-year-olds, there is relatively little setting-based research on the mathematical development of younger children. Clearly, there is need for further research, particularly given that the participants of this study and others (Ginsburg et al., 2008; Perry & Dockett, 2002) are convinced that young children's mathematical development can begin much earlier than age 4 years. The *Mathematical Thinking of Pre-school Children in Rural and Regional Australia: Research and Practice* project is a good beginning. Hopefully, it will stimulate a continuation of the excellent research that has characterised the Australian early childhood mathematics education field over the last 30 years.

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