Mathematics in early childhood: Exploring the issue

Nicola Simmons

This paper explores a number of issues relating to mathematics within children's play experiences in early childhood settings. In particular, what makes mathematical experiences both meaningful and purposeful is considered within the framework of play, as promoted by Te Whariki. In doing so both traditional/instructional and investigative teaching/learning approaches to mathematics and related theories of learning will be briefly examined.

Introduction

In its report on the use of *Te Whariki* (Ministry of Education [MoE], 1996), New Zealand's early childhood curriculum, the Education Review Office (1998) stated:

> The cognitive and intellectual development of children before they enter school is critical to their future educational achievement. Literacy and numeracy are essential to progress at school and children's ability to acquire these skills is influenced by the nature of their early childhood experiences (p. 5).

Cullen (2000) responded to this statement and emphasised the need for teacher expertise in a number of areas:

> If greater attention is to be given to literacy and mathematics in early childhood programmes it is important that all teachers working with young children understand the nature of children's learning in these areas and how to promote this in educational programmes, using methods appropriate for young children (p. 3).

In light of this and because more emphasis was being put on the development of children's numeric skills, I believed I needed to examine my own mathematical knowledge. Through reflection on my own current professional practice I realised that I felt out of my comfort zone when teaching mathematics. Indeed I was contributing to the "incidence in early childhood centres of both ad hoc structured maths teaching and the loose 'maths is everywhere' approach" (Hill, 1995, in Haynes, 2000, p. 102). I realised that increasing my own mathematical pedagogical and content knowledge would enable me to recognise the mathematical potential in children's play experiences (Annings & Edwards, 1999, in Cullen, 2000), thus providing me with the opportunity to teach mathematics more effectively.

The purpose of this paper is to explore a number of issues relating to mathematics within children's play experiences in early childhood settings. Both traditional/instructional and investigative teaching/learning approaches to mathematics and related theories of learning are briefly examined. The contrasting role of the teacher within the two different teaching/learning approaches is then discussed. This paper then considers the question: what makes mathematical experiences both meaningful and purposeful? Common key aspects within an investigative approach to mathematics and the early childhood curriculum, *Te Whäriki,* are explored. The importance of assessment as a tool to enable teachers to respond to children as learners is then discussed. Lastly, this paper examines the provision of mathematically rich experiences.

Teaching/learning approaches to mathematics

The traditional instructional approach to mathematics or the lecture-and-drill method is underpinned by the learning theory of behaviourism (Ginsburg, Klein, & Starkey, 1998, in Baroody, 2000). Both Baroody (2000) and Irwin and Irwin (2000) discuss this theory and argue that in order for children to learn mathematics within this approach their actions need to be rewarded or positively reinforced. Attention is "focused on the consequences of behaviour" (Irwin & Irwin, 2000, p. 32) and not on the children's actual understanding of mathematical processes. In contrast, Hatano (1988), Hiebert and Carpenter (1992), and Rittle-Johnson and Alibali (1999) all argue that "understanding greatly facilitates remembering and applying mathematics" (in Baroody, 2000, p. 64). Because behaviourist teaching approaches often place little importance on the children's understanding of mathematical processes they end up being "spoon-fed mathematics" (Baroody, 2000, p. 61) and are encouraged to learn mathematics by rote. Baroody (2000) asserts that such views shaped the conclusions of Thorndike (1922) and that this led to the lecture-and-drill method which "remains to this day the most widely used way to teach children mathematics" (Baroody, 2000, p. 61).

Within my current practice I frequently teach mathematics in this way. When planning for mathematics it is usually in the form of a group rote learning activity. For example, I use numeral flash cards in the belief that it is the best way for children

to learn to recognise, name, and understand the meaning of numerals. While this approach has a place in teaching mathematics, it needs to be delivered as part of a more balanced teaching/learning approach that actively promotes the mathematical understanding of children.

An "investigative approach" (Baroody with Coslick, 1998, in Baroody, 2000, p. 64) is one which is "purposeful, meaningful, and inquiry based" (National Council of Teachers of Mathematics, 1989, 1991, in Baroody, 2000, p. 64) and that can successfully promote and foster children's mathematical understanding. Investigative approaches enable children to experience mathematics within a context that is meaningful to them. This means that the task must be real to the children, in some sense, and therefore personally interesting.

An investigative teaching/learning approach to mathematics is viewed as congruent with constructivist learning theory. Begg (1999) discussed the research and views of Piaget that underpin constructivism; mainly that children actively construct new knowledge from their experiences that are related to both past and present learning. Children gain such experiences through interactions with their physical and social worlds. Further, Begg (1999) cites von Glasersfeld (1990) who claimed, "all ideas and knowledge gained [are] derived from our experiences – our senses, our acting and our thinking" and argued that "learning is the organisation of these experiences to make a coherent and viable picture of one's world" (p. 1).

The role of the teacher

Within an instructional approach to mathematics, the teacher's role is to act as a "sage on the stage" (Begg, 1999, p. 1). The teacher begins with a behavioural objective, one that is teacher selected rather than necessarily learner centred. For example, the teacher, having decided that the children need to be able to recognise the numbers 1–5, transmits the knowledge to the children who receive it passively (Begg, 1999). The teacher's focus is on the children learning a mathematical skill, often by rote, rather than whether the children understand the mathematics underlying the skill. Therefore, the teacher requires little or no participation from the children. Ultimately the teacher, not the learner, determines both the teaching and learning paths.

In contrast, the teacher's role within an investigative approach to mathematics is to act as an informed other and to scaffold the children's potential learning by building on the knowledge and experiences the children already possess. This assists children in their learning of new concepts or procedures, "by connecting new information or a problem to existing knowledge, children are far more likely to understand it" (Baroody, 2000, p. 64). The theory that supports the teacher's role within an investigative approach is "Vygotsky's (1978, 1986) social-constructivist theory of cognitive development" and in particular his "zone of proximal development (ZPD)" construct (Kirova & Bhargava, 2002, p. 5). Underpinning this theory is the view that learning is more likely to occur if adults or older/more experienced peers mediate children's learning experiences (Baroody, 2000). Learning occurs within a child's ZPD when an adult or informed other scaffolds the child's experience. Scaffolding entails the teacher continually modifying his/her assistance or support within the opportunities or tasks presented, so as to provide the appropriate level of challenge that enables the child to learn (Kirova & Bhargava, 2002). In order to build on and extend the children's understanding of mathematics, the teacher must give careful consideration to the provision of learning opportunities. Ideally the opportunities should promote the freedom of exploration of materials and interactions within the children's physical and social worlds. Within an early childhood setting there are numerous ways of achieving this. For example, explorative opportunities arise through questions and problems being raised by the children as they interact with others within different areas of the centre and also during routines such as meal times as children communicate with others.

Clements (2001) compared the usefulness of instructional and investigative approaches aptly by stating "The most powerful mathematics for a preschooler is usually not acquired while sitting down in a group lesson but is brought forth by the teacher from the child's own self-directed, intrinsically motivated activity" (p. 8).

Meaningful and purposeful mathematics

A number of researchers emphasise the importance of meaningful and purposeful mathematical experiences in which teaching/learning can occur (Clements, 2003; Kirova & Bhargava, 2002; National Council of Teachers of Mathematics, 1989, 1991,

in Baroody, 2000). So, what makes mathematical experiences both meaningful and purposeful?

The core principle of ensuring that mathematics has meaning and purpose is that teaching/learning should be related to, and integrated into children's daily lives. Experiences provided should build on the ideas and skills already possessed by the children, and mathematical ideas should extend from the daily activities, interests, and questions that arise from the children (Clements, 2001). As Perry and Dockett (2002) stated, children's learning occurs much more readily when the task has a clear purpose, and means something to them. This notion embraces the investigative approach discussed earlier, as the tasks are real, meaningful, and purposeful to the children.

From the everyday activities of children such as block building, water play, meal times and stories, opportunities can arise to extend their mathematical knowledge. For example, during meal times individual children can be asked to determine the number of cups that are required so that everyone gets a drink; this encourages thinking about one-to-one correspondence and develops counting skills. By both creating and recognising worthwhile problems and tasks for the children to explore, teachers are providing a real basis for the learning and practicing of mathematics (Baroody, 2000). Encouraging the children to explore their 'own' problems enables them to develop and "devise their own strategies and interact with them as they think or work through situations" (Anderson, 1997, in Baroody & Benson, 2001, p. 157) that build on their prior experiences.

The investigative approach and the early childhood curriculum

Key aspects of investigative approaches to teaching/learning mathematics sit comfortably within *Te Whäriki* (MoE, 1996). Haynes (2000) argued that *Te Whäriki* has a constructivist learning theory underlying its framework, which emphasises the importance of starting from what the learner knows. In the introduction of *Te Whäriki* it is stated that the curriculum "is about the individual child. Its starting point is the learner and the knowledge, skills, and attitudes that the child brings to their experiences" (p. 9). As previously discussed, an investigative approach provides

children with the opportunity to build on and acquire knowledge within a context that is personally meaningful. This is also reflected in *Te Whariki*. Haynes (2000) pointed out that *Te Whariki* highlights the:

> importance of empowerment as a key factor in the growth of the learner: *growth*, defined by the acquisition of knowledge and the ownership of that knowledge and *empowerment*, through the self esteem which develops from the confidence of holding that knowledge and from the process in which the knowledge was gained (p. 95).

Te Whariki promotes a holistic approach to the learning and development of children with its foundation being the learner, and the engagement of the learner within the learning environment. Similarly, Clements (2001) advocates a holistic approach when teaching young children mathematics:

> holistic teaching and learning capitalizes on preschoolers' high level of motivation to learn in a self-directed manner. This teaching promotes a view of mathematics as a positive, self-motivated, self-directed problem-solving activity at the time that children first develop their mathematical beliefs, habits, and feelings (p. 4).

But is the adoption of an investigative approach to mathematics within a holistic curriculum, on its own enough to ensure that the mathematical potential of the experiences provided can be developed to have specific meaning and purpose for individual children? According to the Education Review Office, it is not. In a report on the use of *Te Whariki*, it stated "attendance at an early childhood centre is no guarantee that a child will develop appropriate pre-literacy and pre-numeracy skills as a precursor to school attendance" (1998, p. 5). The report discusses the concern that "*Te Whariki* fails to give clear direction or guidance about what early childhood providers need to do to ensure that they are contributing positively to young children's educational development" (p. 5), and highlights the importance of professional development. Both Cullen (2000) and Haynes (2000) asserted that teachers must develop and extend their own personal subject knowledge in order to fully extend the potential learning of children. Cullen (2000) stated "teachers in early childhood programmes would work more effectively with young children if they had a strong subject knowledge base to inform their work" (p. 5).

Responding to children as learners

In order for a teacher to act as an informed other and scaffold the children's potential learning, they need to draw on their knowledge base about what the children know, understand and are able to learn. It is through the process of assessment that I inform my knowledge base with respect to individual children. Assessment provides "the ways in which, in our everyday practice, we observe children's learning, strive to understand it, and then put our understanding to good use" (Drummond, 1993, in Carr, 1999, p. 11). Assessment enables the teacher to identify where the child is currently at in his/her understanding of a specific concept. Using this information, scaffolding can then be provided for individual children, thus providing an appropriate level of challenge that enables the child to move to an increased level of understanding (Kirova & Bhargava, 2002). Within the context of an early childhood setting, one assessment approach used is that of Learning Stories. These tell a story of the child's learning in a way that applies a credit rather than a deficit approach to assessment. The stories document what children can do rather than what they can't do (Carr, 1998, in Hatherly & Sands, 2002), and acknowledge a holistic approach to development, as promoted by *Te Whariki*. Assessment provides the knowledge to draw on in order for the teacher to provide appropriate experiences and scaffolding that "will be meaningful and engaging to the particular children in the group, individually and collectively" (Clements, 2004, p. 59).

One crucial point that teachers must be aware of as they interpret the information acquired from the assessment process is to see the situation from the child's perspective. The ideas that young children construct can be uniquely different from those of adults (Piaget & Inhelder, 1967; Steffe & Cobb, 1988, in Clements 2004). Clements (2001) argued that teachers of young children "must be particularly careful not to assume that children " 'see' situations, problems, or solutions as adults do" (p. 4). For instance:

> one researcher asked Brenda to count six marbles. Then the researcher covered them up, showed one more, and asked how many he had in all. Brenda said he had one. When the researcher pointed out that he had six marbles hidden, Brenda said adamantly, "I don't see no six!" For Brenda no number could exist without objects to count (p. 4).

As a result of appropriate assessment based on interactions with the children informing the teacher's knowledge base, experiences offered to the children should be meaningful, purposeful and encourage active participation.

Providing mathematically rich experiences

Play is a child's world and allows the child to be a child while enabling growth and development in a completely holistic way. According to Clements (2001), "Quality preschool mathematics … invites children to experience mathematics as they play in, describe and think about their world" (p. 2). Children learn through play (Balfanz, Ginsburg & Greenes, 2003) where they are active participants in experiences that are important to them, thus giving the experience meaning and purpose. As discussed earlier, meaningful and purposeful experiences are an integral component of the successful implementation of investigative teaching/learning approaches to mathematics. So how can the context of play best offer children the opportunity to learn mathematics?

Play is a complex concept and difficult to define. It has been described as "symbolic, meaningful, active, pleasurable, voluntary, rule-governed and episodic" (Fromberg, 1992, in Perry & Dockett, 2002). During play, children are provided with opportunities to engage in experiences and interactions with their physical and social worlds, thus they actively construct new knowledge from their experiences. Within these experiences there is also opportunity for interaction with more skilled or experienced peers. This provides the opportunity for scaffolding to occur (Perry & Dockett, 2002).

Links can be made between the characteristics of play and developing mathematical knowledge and understandings. In relation to Fromberg's description of play as symbolic and episodic, it could be said that 'working' with pattern formats is symbolic and episodic, thus a form of play. Similarly, it is important that the mathematics activity/experience is meaningful, promotes active participation, and has a clearly identified mathematical purpose, which can be provided by play. Children engage in play for the purpose of having fun; if an experience provides enjoyment then perseverance is likely, enabling longer active participation. Play provides

children with a context in which they are able to explore mathematics within situations that are relevant and important to them, making the exploration meaningful.

But according to Balfanz et al. (2003) "play is not enough" (p. 2); they argue that while play is important, children can only discover a certain amount through their own exploration. In order for children to reach their full potential, they need adult guidance. I believe that while adult guidance is an important role in scaffolding children's potential learning, too much adult guidance can result in the pathway of the child's development being completely dictated by the adult. Once the control of the play is taken away from the children, it ceases to be play. Perry and Dockett (2002) advocate that "play is controlled and directed by the players [the children]" (p. 16). Indeed, "Children will often set themselves much more difficult challenges if we give them control of their learning than if it is left to adults" (Griffiths, 1994, in Perry & Dockett, 2002, p. 17).

Conclusion

Mathematics understanding and learning are more likely to occur if experiences are meaningful and purposeful to individual children. This can be achieved through the scaffolding of children's potential learning with the teacher acting as an informed other. However, an awareness of the potential harm in dictating the particular pathway of the child's development is crucial. Minimising this risk requires knowledge and the understanding of the importance of a number of factors: the learning theories that underpin different approaches, the teacher's role, the possession of a wide developmental, curriculum and subject knowledge base, the role of assessment in responding to children and allowing effective scaffolding, and the importance of play. Through careful consideration of the above factors when planning mathematical experiences, teachers can look forward to the reward of children building on and extending their mathematical knowledge with confidence and enthusiasm. With regard to my own future practice, I will endeavour to change and make more use of investigative approaches to teaching/learning mathematics to ensure that the mathematical experiences and opportunities I provide have greater meaning and purpose for the individual children for whom I am responsible.

References

Balfanz, R., Ginsburg, H. P., & Greenes, C. (2003). Early childhood corner: The big math for little kids early childhood mathematics program. *Teaching Children Mathematics, 9*(5), 264-274. Retrieved 6 August, 2004 from the World Wide Web: http://80-infotrac.galegroup.com.aceezproxy01n.ace.ac.nz/

Baroody, A. (2000). Does mathematics instruction for three- to five-year-olds really make sense? *Young Children, 7*(4), 61-67.

Baroody, A., & Benson, A. (2001). Early childhood corner: Early number instruction. *Teaching Children Mathematics, 8*(3), 154-158. Retrieved 6 August, 2004 from the World Wide Web: http://80-infotrac.galegroup.com.aceezproxy01n.ace.ac.nz/

Begg, A. (1999). *Learning theories and mathematics: A, B, C, D and E.* Paper presented at the 6th biennial conference of the New Zealand Association of Mathematics Teachers, Dunedin.

Carr, M. (1999). Some thoughts about effective assessment. *Early Education, 21* (Spring/Summer), 11-21.

Clements, D. (2004). Major themes and recommendations. In D. H. Clements, J. Sarama, & A. DiBiase (Eds.), *Engaging young children in mathematics: Standards for early childhood mathematics education* (pp. 7-72). New Jersey: Lawrence Erlbaum.

Cullen, J. (2000). The early years conceptual issues and future challenges. *New Zealand Research in Early Childhood Education, 3,* 3-11.

Education Review Office. (1998). *The use of Te Whariki.* Retrieved August 6, 2004 from the World Wide Web: http://www.ero.govt.nz/Publications/eers1998/TeWhariki/TeWhariki.htm

Hatherly, A., & Sands, L. (2002). So what is different about learning stories? *The First Years: Nga Tau Tuatahi, 4*(1), 8-12.

Haynes, M. (2000). Mathematics education for early childhood: A partnership of two curriculums. *Mathematics Teacher Education & Development, 2,* 93-103.

Irwin, K. C., & Irwin, R. J. (2000). Behaviourism is not the opposite of constructivism. *New Zealand Mathematics Magazine, 37*(2), 32-33.

Kirova, A., & Bhargava, A. (2002). Learning to guide preschool children's mathematical understanding: A teacher's professional growth. *Early Childhood Research & Practice, 4*(1). Retrieved 6 August, 2004 from the World Wide Web: http://ecrp.uiuc.edu/v4n1/kirova.html

Ministry of Education. (1996). *Te Whariki: He Whäriki Mätauranga mö ngä Mokopuna o Aotearoa: Early Childhood Curriculum.* Wellington, NZ: Learning Media.

Perry, S., & Dockett, S. (2002). Playing with maths. *Square One*, *12*(3), 14-17.