In posing such a question about play and its potential to provide impetus for mathematical thinking and understanding, the aim is to offer one way of explaining the relationships between play contexts and their potential for fulfilment of numeracy education goals. It has been well documented that the social and perceptual dimensions of play experiences lead children to come to know not only their physical and social worlds (Bredekamp & Copple, 1997; Dockett & Fleer, 1999) but they also provide key opportunities for learning to be literate (Neuman & Roskos, 1997; Rowe, 1994) and numerate (Macmillan, 1997, 1998a, 1998b, 1999; Mannigel, 1998). Mathematics education literature also encourages us to think about mathematical meanings as permeating our physical, perceptual and abstract worlds. Some time ago, for example, in his study of cultures around the world, Bishop (1988) identified playing along with counting, measuring, locating, explaining and designing as Six Universal Mathematical Activities. More recently, understanding mathematics as having social, practical, creative and aesthetic purposes has been brought to our attention from a range of sources (Alrø & Skovsmose, 1996, 1998; Jaworski, 1994; Lerman, 1996; Noss, 1998; Otte, 1997). Closer to home, numeracy is constantly being presented by authors in this journal as being facilitated within imaginative and social contexts. Much of this thinking emanates from numeracy being perceived as involving ‘using some mathematics to achieve some purpose in a particular context’ (Australian Association of Mathematics Teachers, 1997, p. 13), and as incorporating number, spatial, data and formulae senses (p. 11):

Learning through play is an idea explored in detail by AGNES MACMILLAN. In particular, Agnes highlights the strong links between contextual play and the development of numeracy skills.
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- **number sense** incorporates an ability to use numbers and an appreciation of number and number relationships;
- **data sense** involves the use of statistical and measurement information;
- **spatial sense** involves the use of spatial, visual and location information; and,
- **formulae sense** involves the use of formulae, graphs, symbols, signs.

For the study being reported here, pre-service teachers in an early childhood (birth to eight years) Bachelor of Education course adopted teacher roles in preschool settings as they introduced numeracy kits as one of the play activities being set up for group time. This project was an extension of another carried out in schools and reported elsewhere (Macmillan, 2001). The children’s interactions during the play sessions were analysed according to the four numeracy senses outlined above. Adult interactions were interpreted as being collaborative, responsive, or ‘mediating’ because the children’s knowledge base was respected and accepted as they presented perceptual or linguistic models of mathematical terms, explanations, strategies and procedures (Halliday, 1978, 1994; Macmillan, 1997, 1998a; Meira, 1995; Nunes, 1996).

During a five-week period, three play sessions per week were tape and video recorded and selected transcripts from three of the preschool settings are being used here to highlight the numeracy content and the teaching strategies. The kits were identified according to their imaginative focus and related contents as **Garden Play**, **Puppet Play** and **Pond Play**. The table below (Figure 1) summarises the numeracy focuses of each activity, and the curricular or theoretical links used to support the content and design of the kit.

**Figure 1. Summary of the numeracy kits and content focuses.**

<table>
<thead>
<tr>
<th>Play Activity</th>
<th>Description</th>
<th>Numeracy focus and theoretical links</th>
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<tbody>
<tr>
<td><strong>Garden Play</strong></td>
<td>This kit included natural and synthetic materials: flowers, seed pods, cones, sand, planting pots constituted the basic kit. Other materials introduced included garden creatures: insects, beetles, frogs, turtles, snakes, butterflies. A container of foam shapes, pieces of paper and containers of glue were also provided. Children could create their own gardens and pictures of the gardens using the shapes.</td>
<td>Number sense: ordinality, cardinality, seriation, matching of numbers to 10 (Arthur, Beecher, Dockett &amp; Farmer, 1996).</td>
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<tr>
<td><strong>Puppet Play</strong></td>
<td>This kit consisted of a collection of 25 finger puppets representing five different animals, each animal having an imprint of five 2-D geometric shape. Gradually added were a collection of small laminated shape cards, dot cards of numbers 1–5, coloured paddle pop sticks, play dough, animals on sticks, puzzles and books. Paper and coloured texta colours were available nearby for use.</td>
<td>Number sense: matching, sorting, classifying (Yelland, Butler &amp; Diezman, 1999) Spatial sense: knowledge of 2-D shapes and their elements as a precursor to knowledge of 3-D shapes (Mannigel, 1998).</td>
</tr>
<tr>
<td><strong>Pond Play</strong></td>
<td>This kit consisted of a large piece of green felt (to represent a grassy area), a piece of blue felt (to represent a pond), an assorted collection of plastic animals, a large shape dice, shape cards (for each participant to choose their shape) and serially numbered discs for the numbers 1–10 (for building the bridge) across the pond. The children choose an animal and when their colour comes up they can select the next numbered disc to build a bridge across the pond for their animal. When they reach the other side they can choose from a selection of animal and shape books to read.</td>
<td>Number sense: cardinality, cardinality, seriation, matching of numbers to 10 (Arthur, Beecher, Dockett &amp; Farmer, 1996). Spatial sense: colour and shape classification and identification (Morgan, 1989).</td>
</tr>
</tbody>
</table>
Number and data senses

Five children were engaged in the Garden Play one morning when toy garden creatures were introduced. Gradually the children became more interactive, observing and commenting on each other’s ‘gardens’. In the following conversation, for example, the children’s number sense was evident in the non-verbal manipulation of the objects of play as they were classified, organised and arranged in rows and various arrays. Increasingly, these manipulations of objects were accompanied by numerical and non-numerical quantifiers and qualifiers. With the locating and positioning of objects in particular ways at particular times, and comparisons of size and length, the context also facilitated opportunities for spatial and data senses to be activated.

Child 1: I’m making a garden.
Child 2: I don’t need this one.
Child 1: These ones don’t match into our garden.
Teacher: Don’t they? Why don’t they match?
Child 1: ‘Cause our garden is different to other gardens.
Teacher: How are they different?
Child 2: Yeah, they are different gardens.
Child 1: These ones match to them.
Teacher: These ones match to it but these ones are different?
Child 1: Yeah. These ones are prickly. There we are. My garden is going to grow.

The Puppet Play kit provided felt finger puppets where each of the five types of animal had a different shape on its body. It allowed a variety of matching, classifying and patterning activities to be initiated by the children. The children could, for example, experience one-to-one correspondence by placing one of each shape, or one of each type of animal all with the same shape, on each of the five fingers of one hand. A typical spontaneous response to the activity, evident in the following conversation, was to gather up a random collection and see how many they had collected:

Child 1: I’ve got five.
Child 3: I’ve got five.
Child 2: I’ve got heaps more than anyone.

Child 3: One, two, three!
Child 3: Why do you got thirty?
Child 2: ‘Cause I got them more quickly. I got the first one.
Child 4: I only got three triangles.
Child 2: I don’t care ‘cause I’ve got thirteen.

[She holds her cards in her hand while leaning over the table and observing the other children.]

The relationship between number sense, data sense and the kinds of creative construction or designing activities (Bishop, 1988) afforded by play contexts was evident throughout the play sessions. In the third week of the Puppet Play, two colours of play dough, paddle-pop sticks, large wooden pegs, and a selection of animals on sticks were added to the play table, and the children were invited to make a zoo for their animal puppets. The children applied identifying attributes to the objects and actions of play (a little one, all together), and used comparative non-numerical quantifiers (more, some more, bigger than, too many, too small, a little bit more, any more) and qualifiers (different).

Spatial sense

Opportunities for facilitating children’s spatial sense were an inherent aspect of the activities as concepts of position, location, direction were associated with designing and constructing. Concepts related to the structural, symmetrical properties of geometric shapes were a prominent aspect of three of the activities. Identification and nominal labelling of the shapes occurred as a natural outcome of interacting with the resources provided. The Pond Play activity combined opportunities for some open-ended engagement in the arrangement of the animals and plants around the pond, but also introduced the children to turn taking. During the early sessions, the adult set out ‘the pond’ for the children at the beginning of the session, but he soon realised that the children preferred to lay out the pond them-
selves. Subsequently they began to contribute to the numeracy meaning making by asking questions and demonstrating an interest in rational and abstract thinking:

‘Where’s all the fishes?’
‘Where does this branch go?’
‘Is there any more things in the bucket?’
‘How come there are big ones and little ones?’
‘Mine’s across there.’
‘I’m going to put this tree with the bird.’
‘Now it’s your turn, S.’
‘It’s S’s turn to put it on.’
‘Mine’s going here.’
‘I’m putting the tree over there.’
‘Can I do it this way?’
‘Now we have to put them next to each other, OK?’

As the shape die was rolled, the children commented on the shapes that came up:

‘These are rectangles and that is a triangle.’
‘Circle for S.’
‘I am having the square.’

From these and the other interactions that followed, it seemed that the rule-bound aspect of turn taking demonstrated that it was not only a social skill but that it also involved spatial sense as the children understood their position in relation to others, as well as the directional and rotational aspects of turn-taking. The children also seemed to be interpreting the need for precision and order when they used expressions such as ‘now we have to’, ‘can I do it this way’, ‘they’re not right’, ‘do we need to’, ‘I already know how to do it’.

Formulae sense

The development of formulae sense is linked to individual and sociocultural needs and desires for efficient and meaningful ways to record and value symbolic representations of mathematical ideas, actions or experiences (Australian Association of Mathematics Teachers, 1997). One of the two activities offering opportunities for the children to document their numeracy experiences was the Puppet Play. In this setting the class teacher offered to compile the children’s recordings as a ‘big book’ and use it during whole group language sessions. The outcome of this follow-on strategy was that there was inclusion of the pre-service student’s practice into class routines and subsequent indication to parents and children of the recognition and valuing of her work.

The children’s number, spatial, and data senses were also represented in the twenty-one spontaneous drawings that constituted the Puppet Play ‘big book.’ Generally speaking, formulae sense was evident in that the drawings were symbolic abstract representations of perceptually available objects (mostly from their constructions), imagined experience (from the zoo play), and their own knowledge base (about real-world phenomena, such as spiders). More particularly, analyses of the drawings based on Bishop’s (1988) explanations of the activities of designing, counting, measuring and locating allowed inferences to be made about the mathematical concepts related to number, spatial and data senses. These were demonstrated throughout the children’s recordings and accompanying interactions. There were representations of:

• a child’s hands and fingers which were, in a sense, the ‘figurative technology’ (Steffe & Cobb, 1988) used to hold and play with the puppets, or could be interpreted as being linked to what Bishop refers to as ‘symbolic technology’ (Figure 2);
• numerals, their names, an assortment of the letters (Figure 3);
• the distinguishing attributes of colour and size, evident in the child’s dictated caption, ‘The tiger was tall’ (Figure 4);
• grouping of like objects (Figure 5);
• enclosures representing fences, strings of beads (Figure 6);
• identifying the five basic geometric shapes and distinguishing them from each other (Figure 7);
• the move from an abstract context to social context when the child extended a drawing of a spider with the correct number of body parts, to a ‘counting game’ where he counted on from eight to as high as he could count, engaging in synchronous verbal and symbolic one-to-one correspondence (Figure 8);
• consistency of perspective (Figure 9).
Numeracy play — how mathematical is it?

Figure 2. Figurative technology.

Figure 3. Literate, numerate symbols, signs.

Figure 4. Distinguishing attributes of colour and size.

Figure 5. Grouping of like objects.

Figure 6. Enclosures representing fences, strings of beads.

Figure 7. Distinguishing a circle from a triangle.

Figure 8. Representing social and imaginative activity.

Figure 9. Consistency of perspective.
**Responsive teaching strategies**

Analyses of the transcripts demonstrated that the concepts, skills and strategies of the mathematics knowledge base could be modelled and used by the adults in ways that protected the children's control of the play. Children's natural interests, needs and spontaneous, contributions were accepted, valued and responded to collaboratively. In order to illustrate the nature of these supportive and responsive teaching strategies the following examples are offered.

- **Clarifying/elaborating**
  - ‘This one here’s number one. Can you find your number one?’
  - ‘That goes with the tree A’s holding.’

- **Recognising/appreciating**
  - ‘Wow! Look at all that matching!’
  - ‘You’re doing a great job there. You have all the trees there.’
  - ‘They are beautiful, aren’t they?’

- **Confirming**
  - ‘There’s only one, is there?’
  - ‘You used them all.’
  - ‘Oh, you’re a pretender!’
  - ‘You can do it wherever you want to, A.’
  - ‘I looks like a real one.’

- **Encouraging reflection by asking assisting/checking questions**
  - ‘Do you need more?’
  - ‘Does that match?’
  - ‘Would you like some more numbers?’
  - ‘Do you want mine? Here.’
  - ‘What about the lily pads?’
  - ‘Do we need to put them all in one dish?’

- **Pretending not to know the answer**
  - ‘Truly, I can’t count!’

- **Creating relevance by making links with the child’s current knowledge**
  - ‘That’s nearly as old as you.’
  - ‘There’s a fat brick and a skinny brick.’

- **Modelling curiosity**
  - ‘I wonder if mine’s a circle?’

- **Inviting imaginative involvement**
  - ‘Looks like a wiggly worm.’

- **Inviting participation by offering choice**
  - ‘You can do it wherever you want to, A.’
  - ‘How many do you think I’ll need?’
  - ‘Who’s going to put a card out first?’
  - ‘What do you think you might like to do now?’
  - ‘Where do you want me to put this one? In here, near the ladybug?’

- **Inviting participation by offering challenge**
  - ‘Let’s count the red ones you’ve used.’
  - ‘How many do you think I’ll need?’

**Concluding comments**

This article has provided explanations of the links between numeracy and perceptually attractive and socially participatory contexts. It has also aimed to highlight the preciousness of young children’s spontaneously produced numeracy explorations, especially in regard to their potential to generate numerate confidence and competence. Australia’s national *Policy on Numeracy Education in Schools* (Australian Association of Mathematics Teachers, 1998, p. 3), states that numeracy is ‘context specific’ and ‘relevant’ to everyday-life experiences. The children’s play data suggest that numeracy education principles were congruent with early childhood education philosophies and practices, particularly when they were able to:

- ‘discern and respond to an individual student’s numeracy learning needs,’
- build knowledge and understanding of mathematical concepts by allowing ‘connections to be made between these [understandings] and our cultures,’
- and ‘build the capacity and confidence to use mathematics’ (p. 3).

In coherence with early education premises, numeracy goals appeared to be incorporated into play when the children were able to:

- experience mathematical content as an intrinsic part of the context;
- use mathematical concepts to develop number, spatial, data and formulae senses;
• become conscious of the mathematical nature of the context gradually and comfortably without the need for precision and accuracy becoming problematic for them;
• fulfil self-initiated goals and purposes;
• control the flow of events so that the mathematical meanings were realised through participation in negotiable and engaging activities;
• receive mediating support;
• explore, imitate, test and check, and gradually become more confident and competent in the ways of saying and doing things in culturally conventional ways.

References


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