Learning Stories and Children's Powerful Mathematics

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Abstract

The approaches to teaching and learning mathematics in Australian preschools and schools can be quite different. These differences arise from what can be termed different "cultures" within the prior-to-school and school settings. Even the first years of school can be characterized by teacher-centered, syllabus-driven lessons and written, group-based assessment, while the preschools tend to adhere to their child-centered, play-based approaches. The result of these differences can be a hiatus in the children's mathematics learning and the teachers' assessment of this learning. This paper reports on one attempt to bridge this gap, not, as so often happens, by "forcing down" the primary school curriculum into the preschool but by maintaining a focus on appropriate learning approaches in this period of the children's lives. The Southern Numeracy Initiative (SNI) was established in 2004 in high schools, primary schools, and preschools situated in the southern suburbs of Adelaide, South Australia. Its general aim was to improve mathematics and numeracy outcomes through a sustained, collaborative program of professional development and action research, particularly in the areas of pedagogy and assessment. This paper reports work done with preschool educators as part of SNI. It traces how "powerful ideas" in mathematics were identified in current preschool practice, how they were linked to the Developmental Learning Outcomes in the mandatory curriculum documents, and how the technique of learning stories (narrative assessment) was established as a valid assessment regime compatible with key principles of preschool education. The professional development focus on children's powerful mathematical ideas, combined with action research that encouraged educators to identify these ideas within children's experiences and to document these through learning stories, form the basis of this paper.

Introduction

In Australia, pressure on first-year-of-school teachers to lift their expectations of young children's mathematical potential has exerted pressure on prior-to-school educators and parents to ensure, wherever possible, that children starting school can perform at a higher mathematical level than previously expected and that they are able to succeed at more formal mathematics than had previously been the case (Perry & Dockett, 2005a). There is often conflict between this increase in formality and the play-based, child-centered philosophies of prior-to-school settings (Thomson, Rowe, Underwood, & Peck, 2005).

The Southern Numeracy Initiative (SNI) was established in 2004 among five high schools, sixteen primary schools, and six preschools in two districts south of Adelaide. The aims of SNI included the following:

- to develop and implement successful teaching and learning practices to improve numeracy, and
- to challenge teachers to explore their beliefs and understandings about how children develop their understanding of mathematics and how this effort can be supported through the teaching program.

The preschools in SNI had some concerns about the direction being taken by the schools involved, especially in terms of apparent tension between the formality of instruction and the methods of assessment chosen by the schools and the child-centered, play-based approaches that characterized their early childhood programs. As a consequence, two of the authors of this paper were invited to work with the preschool educators in SNI to develop a program aimed at improving teaching, learning, and assessment practices in the numeracy development of young

children. The key research question for the overall early childhood project was "How can the powerful mathematical ideas that are displayed by young children before they start school be recognized and celebrated in a valid manner within the context of a mandated reporting regime and a child-centered, play-based approach to learning?"

In this paper, a professional development program for preschool educators that was designed to help answer this research question is described. The effectiveness of the professional development program, particularly the stimulus it provided for educators to engage in action research as they investigated young children's mathematical experiences, is analyzed through examples of learning stories and reflective comments from the participants.

Powerful Mathematical Ideas

Preschool educators tend, at least in Australia, to reject the divided, content-based approach to mathematics curriculum, which is often used in schools (Australian Association of Mathematics Teachers and Early Childhood Australia, 2006; Doig, McCrae, & Rowe, 2003). There is, however, general agreement that all children in their early childhood years are capable of accessing powerful mathematical ideas that are both relevant to their current lives and form a critical foundation for their future mathematical learning and that children should be given the opportunity to access these ideas through high-quality child-centered activities in their homes, communities, and prior-to-school settings (Kilpatrick, Swafford, & Findell, 2001; Perry & Dockett, 2005a; Thomson et al., 2005).

Two of the authors of this paper have constructed a list of powerful mathematical ideas that they have used for some time to plan, observe, facilitate, and assess young children's mathematical learning (Perry & Dockett, 2002, 2005b). Their list bears many similarities to other such lists (see, for example, Greenes, Ginsburg, & Balfanz, 2004; National Council of Teachers of Mathematics, 2000) and consists of the following powerful mathematical ideas:

> *Mathematization*: The process of generating mathematical problems, concepts, and ideas from real-world situations and using mathematics to attempt a solution to the problems so derived is called mathematization.
>
> *Connections*: Mathematics learning is related to learning in other areas; learning in one area of mathematics can be relevant to learning in another area of mathematics; and mathematics should be relevant to the contexts in which the child is experiencing it.
>
> *Argumentation*: The process that allows children to justify their own mathematical thinking and to understand that of other people is called argumentation.
>
> *Number sense and mental computation*: Number sense includes "a person's general understanding of numbers and operations along with the ability and inclination to use this understanding in flexible ways to make mathematical judgments and to develop useful and efficient strategies for dealing with numbers and operations" (McIntosh, Reys, & Reys, 1997, p. 322).
>
> *Algebraic reasoning*: In the early childhood years, much algebraic reasoning is embodied in work on patterns and relationships. Concepts such as equality, sequence, variability, and symbolization are also relevant.
>
> *Spatial and geometric reasoning*: Children in the early childhood years begin to reason about shapes by considering certain features of the shapes. Spatial thinking plays a role in making sense of problems and in representing mathematics in different forms such as diagrams and graphs.
>
> *Data and probability sense*: Data play a critical role in our modern society. Much information uses statistical ideas and is transmitted through graphs and tables.

> Children at all levels of schooling need to be able to deal with these data in sensible ways. That is, they need a sense about data. Chance (probability) experiences are had by almost everyone every day. Children need the opportunity to develop their thinking about chance and its quantification so that they are able to build on the informal chance experiences they will have in their lives and be in a position to make sensible decisions in situations of uncertainty.

Developmental Learning Outcomes

The South Australian Department of Education and Children's Services is responsible for the education of children in preschools, primary schools, and secondary schools throughout the state. A key curriculum document across this broad span is *The South Australian Curriculum, Standards and Accountability (SACSA) Framework*(Department of Education, Training and Employment, 2001). Educators in South Australian preschools and schools are held accountable for using this framework. In the preschool year, this accountability for children's learning is assessed against eight Developmental Learning Outcomes (DLOs)—broad, observable, and assessable consequences of the curriculum that reflect the integration of learning and development and allow for the different developmental pathways of individual children. These DLOs are

- Children develop trust and confidence.
- Children develop a positive sense of self and a confident personal and group identity.
- Children develop a sense of being connected with others and their world.
- Children are intellectually inquisitive.
- Children develop a range of thinking skills.
- Children are effective communicators.
- Children demonstrate a sense of physical well-being.
- Children develop a range of physical competencies.

This paper reports how the powerful mathematical ideas and the developmental learning outcomes were brought together by a group of practicing early childhood educators into a numeracy matrix that encouraged the educators to plan, implement, and assess their practices. It also considers the use of learning stories by the early childhood educators to assess the mathematics learning of preschool children.

Constructing the Numeracy Matrix

Two of the authors of this paper worked with a small group of early childhood educators for two days in 2005 and two days in 2006 as part of the professional development component of the SNI. On the first day, background information was presented and discussed on the nature of powerful mathematical ideas and their relevance to early childhood. Participants agreed to use the powerful mathematical ideas presented in their planning and assessment of children's learning outcomes—part of the action research element of the SNI project. As well, participants were introduced to the *learning stories* (narrative assessment) methodology for assessment (Carr, 2001) and were invited to use this methodology in their settings. The second professional development day emphasized links between the developmental learning outcomes from the *SACSA Framework*and the powerful mathematical ideas introduced on the first day. During the second day, participants were introduced to the notion of the numeracy matrix and provided with some exemplary cells in the matrix. Part of their task on this day was to complete other cells in the matrix. The third professional development day was held in March 2006 and allowed the early childhood educators to share their experiences with the numeracy matrix and with the

learning stories assessment approach. A further meeting in June 2006 continued the refinement of the matrix and the development of the educators' expertise in using it in their settings, particularly in terms of using it to analyze their learning stories.

The Numeracy Matrix

The theoretical basis for the numeracy matrix is that the key determinants of children's successful outcomes are the pedagogical relationships and practices of educators (Laevers & Heylen, 2004). Hence, the elements of the matrix that bring the DLOs and the powerful mathematical ideas together are "pedagogical questions"—questions asked of early childhood educators as to what practices they are using to ensure that their children's learning outcomes for both the powerful mathematical ideas and the DLOs are developing. The numeracy matrix constructed during the SNI professional development days consists of 56 cells (8 DLOs X 7 powerful mathematical ideas) in which each cell provides examples of pedagogical questions early childhood educators can ask themselves as they teach toward, assess, or report on the DLOs while, at the same time, taking cognizance of the appropriate mathematical development of their children. An example of one of the cells of the numeracy matrix is presented in Table 1.

Table 1

An Example of a Cell from the Numeracy Matrix

Powerful Mathematical Idea	**Developmental Learning Outcome: *Children develop a range of thinking skills.***
Data and Probability Sense	How do we encourage children to develop a notion of fairness in their lives? In what ways do we provide opportunities for children to monitor change over time?

In this cell are two pedagogical questions that challenge early childhood educators to inquire as to what they are doing to help children develop both the mathematical idea and the developmental learning outcome. The answers to these questions will affirm those educators who are working toward these goals, as well as suggest to them that more activities might be needed to help the children develop further. The questions will also stimulate educators who have not considered their practices in these areas to investigate the relevance of current activities and practices or the need for new practices. These pedagogical questions have relevance to other key learning areas as well as mathematics, thus emphasizing integration of mathematics learning with other learning areas. Moreover, the matrix presents mathematical learning for young children as an integrated whole that allows children and educators to explore without necessarily adhering to a linear route along a prescribed trajectory. This design makes the matrix much more attractive to early childhood educators steeped in play-based, child-centered pedagogies than traditional teacher-centered mathematical instruction often found in schools. Such an approach fits well with other current statements on mathematical learning for young children (Australian Association of Mathematics Teachers and Early Childhood Australia, 2006; Greenes, Ginsburg, & Balfanz, 2004; National Association for the Education of Young Children & National Council of Teachers of Mathematics, 2002).

The numeracy matrix is, by its very nature, a work in progress. As the early childhood educators using the matrix have become more confident and competent, they have suggested changes. Some mathematics educators who have studied the matrix have suggested possible changes on the basis of recent research in their field—research that is not normally available to practicing early childhood educators. The matrix is a dynamic reflection of the knowledge of the educators using it and, as such, should be expected not only to be grounded in the contexts in which these educators work but to change as their knowledge changes.

However, for educators who have not undergone the almost two years of growth embodied by the numeracy matrix and the ideas supporting it, the matrix can still provide stimulation for their

own journeys. Hence, it is presented here in its current entirety.

For convenience, the numeracy matrix has been organized into two parts—one dealing with the powerful mathematical process ideas (Table 2) and one with the powerful mathematical content ideas (Table 3).

Table 2
Process Matrix

Developmental Learning Outcome	Mathematization	Connections	Argumentation
Children develop trust and confidence.	How do we encourage children to take risks as they seek to find the mathematics in everyday situations? What opportunities and support do we give children to choose to play with and participate fully in mathematical situations arising from their worlds?	How do we encourage children to play and interact purposefully with the mathematics they experience in their lives? What opportunities and support do we give children to manage and work with different contexts in which a mathematical idea can occur?	What opportunities and support do we give children to explore and take risks as they justify their mathematical thinking? How do we encourage children to demonstrate flexibility and to manage different mathematical ideas as they are presented to them by peers?
Children develop a positive sense of self and a confident and personal group identity.	How do we encourage children to accept the challenge of finding mathematics in everyday situations and to use this mathematics to solve problems arising from the situation? What opportunities do we provide for children to participate actively in collaborative mathematical problem solving and problem posing? What opportunities do we provide for children to explore different perspectives as they attempt to solve mathematical problems?	How do we encourage children to feel that they belong to a mathematical learning community with shared values and responsibilities? How do we encourage children to respond positively to the mathematical ideas and strategies of others? What opportunities do we provide for children to explore different mathematical ideas through collaborative group work?	How do we encourage children to develop and maintain respectful relationships with adults and children even though they may not agree with their mathematical ideas? How do we encourage children to help develop agreed values and sociomathematical norms of behavior in their groups?
Children develop a sense of being connected with others and their worlds.	How do we encourage children to represent their mathematical thinking through the use of symbols, including words and pictures? How do we encourage children to use technology to help them solve mathematical problems? What opportunities do we provide for children to investigate mathematical similarities, differences, and patterns in their lives?	How do we encourage children to contribute to collaborative group work in mathematics through taking on a variety of roles? How do we encourage children to gain knowledge of and build respect for mathematical strategies used by other people? What opportunities do we provide for children to connect the different mathematical ideas they learn?	How do we encourage children to contribute constructively to mathematical discussions and arguments? How do we encourage children to question why their and other people's mathematical ideas work? What opportunities do we provide for children to communicate their own mathematical ideas to a respectful group of peers?

Children are intellectually inquisitive.	What opportunities do we give children to experiment with mathematical concepts and representations in problem solving and investigation? How do we encourage children to gather information and ask questions that might be answered by this information?	What opportunities do we give children to investigate mathematical ideas that are part of the local natural and constructed environment? How do we encourage children to use mathematics to be critical consumers of everyday products? How do we assist children to find connections between different mathematical concepts and representations?	What opportunities do we give children to put forward a mathematical argument and to justify it? How do we assist children to gain confidence in their ability to explore, hypothesize, and make appropriate choices in their mathematics?
Children develop a range of thinking skills.	How do we encourage children to use the processes of play, reflection, and investigation to solve mathematical problems? What opportunities do we provide to reflect upon and communicate their mathematical thinking?	How do we encourage children to use mathematics to describe and analyze their experiences? What opportunities do we provide for children to reflect upon and respect diversity and connections between people's mathematical knowledge and strategies?	How do we encourage children to participate in group discussion and justification about the solution of mathematical problems? What opportunities do we provide for children to suggest alternative solutions to mathematical problems?
Children are effective communicators.	How do we encourage children to talk about and represent their efforts to solve mathematical problems? What opportunities do we provide for each child to demonstrate that symbols are a powerful means of communicating mathematical ideas but that they are not the only way?	How do we encourage children to use different communication strategies to organize and clarify their mathematical thinking? What opportunities do we provide for each child to link their mathematics learning into language and literature experiences?	How do we encourage children to interact with others to explore ideas, negotiate possible solutions, and share their mathematical learning? What opportunities do we provide for each child to use different communication strategies to help clarify his or her and his or her peers' mathematical thinking?
Children develop a sense of physical well-being.	What opportunities do we provide for each child to demonstrate enthusiasm for new mathematical tasks? How do we encourage children to celebrate their successes in mathematics?	What opportunities do we provide for children to use mathematics to help predict and manage change in their daily lives? How do we encourage children to use mathematics to increase their knowledge and understanding about physical health and capabilities?	What opportunities do we provide for children to develop confidence in expressing their mathematical ideas? How do we encourage children to celebrate their efforts and achievements in mathematics learning?
Children develop	How do we encourage children to	How do we encourage children	How do we encourage children to

a range of physical competencies.	actively explore mathematical problems and investigate relevant problems through mathematics?	to move confidently in space and perform different movement patterns with growing spatial awareness?	integrate their mathematical thinking with their communication skills so that they can justify their opinion?

Table 3

Content Matrix

Developmental Learning Outcome	Number Sense and Mental Computation	Algebraic Reasoning	Spatial and Geometric Thinking	Data and Probability Sense
Children develop trust and confidence.	How do we encourage children to use their own thinking strategies? What opportunities do we give children to demonstrate flexibility and make choices? What opportunities and support do we give children to take risks when developing understandings about number?	How do we encourage children to explore patterns? What opportunities and support do we give children to manage change as they engage with pattern-making activities?	How do we encourage children to initiate and participate purposefully in spatial tasks? In what ways are children able to demonstrate flexibility and make choices when playing with collections of everyday shapes and objects?	How do we encourage children to make choices in their lives? In what ways are children able to explore and take risks in their own lives?
Children develop a positive sense of self and a confident and personal group identity.	How do we provide opportunities for children to experiment and think about number in different contexts, including their own family group, traditions, and rituals? What opportunities do we provide for children to seek new challenges and persist in their problem solving?	In what ways do we encourage children to explore their place in the patterns of traditions and rituals in their families? How do we encourage children to explore different perspectives in mathematical problem solving?	In what ways do we encourage children to explore relationships among collections of shapes? How do we encourage children to explore different perspectives in art and spatial ideas?	In what ways do we encourage children to explore data collected from their environment and to record these data? How do we encourage children to begin to recognize, discuss, and challenge unfair attitudes and actions?
Children develop a sense of being connected with others and their worlds.	How do we encourage children to play with number? How do we encourage children to represent number in a variety of ways?	How do we encourage children to explore relationships through making and continuing patterns? What do we do to encourage children to use symbols and different representations of their mathematics? What opportunities do we provide for children to develop awareness of similarities, differences,	How do we encourage children to explore shapes of living things? What do we do to encourage children to use visual representations in recording their spatial thinking? What opportunities do we provide for children to develop awareness of similarities and differences among	How do we encourage children to explore groups to which they belong, based on particular attributes? What opportunities do we provide for children to gather data on living and nonliving aspects of their environments?

		patterns, and changes through their mathematical activity?	shapes and objects?	
Children are intellectually inquisitive.	What opportunities do we give children to explore, hypothesize, take risks, and engage in symbolic and dramatic play with confidence?	What opportunities do we give children to experiment with word, language, number, and shape patterns? How do we encourage children to explore patterns using their senses? How do we assist children to use pattern making and pattern continuation for problem solving and investigation?	What opportunities do we give children to explore their local environment and record what they see using visual means? How do we encourage children to analyze critically the shapes found on the supermarket shelves? How do we assist children to compare and classify shapes?	What opportunities do we give children to investigate different forms of data representation? How do we encourage children to interpret data arising from the use of everyday products? How do we assist children to gather information, ask questions, seek clarification, and consider possibilities about their own lives?
Children develop a range of thinking skills.	How do we encourage children to generate a range of ideas and to use the processes of play, reflection, and investigation to find answers to problems?	How do we encourage children to use patterns to generate mathematical ideas? In what ways do we provide opportunities for children to reflect upon their mathematical pattern making?	How do we encourage children to participate in group discussions and brainstorms around the properties of shapes? In what ways do we provide opportunities for children to use their imagination to generate interesting shapes or patterns?	How do we encourage children to develop a notion of fairness in their lives? In what ways do we provide opportunities for children to monitor change over time?
Children are effective communicators.	How do we encourage children to talk about and represent their findings?	How do we encourage children to demonstrate an understanding that symbols are a powerful means of communication? What opportunities do we provide for children to engage in symbolic play?	How do we encourage children to use different communication strategies to describe shapes and their properties? What opportunities do we provide for children to play with shapes and communicate their findings in a variety of ways?	How do we encourage children to use the language of chance? What opportunities do we provide for children to explore the ideas and concepts of data representation?
Children develop a sense of physical well-	What opportunities do we provide for each child to accept new challenges,	What opportunities do we provide for children to predict and manage	What opportunities do we provide for children to make discoveries	What opportunities do we provide for children to predict and manage

being.	make new discoveries, and celebrate effort and achievement?	change in their daily routines and record the patterns of their lives? How do we encourage children to engage in a variety of active and quiet activities in order to experience a balance?	that are new to them about shape and space? In what ways do children demonstrate enthusiasm for spatial thinking?	change in their daily routines? In what ways do children demonstrate enthusiasm in approaching the ideas of chance?
Children develop a range of physical competencies.	In what ways do we establish an environment that promotes children's exploration?	How do we encourage children to explore patterns in shape and space? In what ways do we assist children to represent varied physical activities and games through patterns and symbols?	How do we encourage children to move confidently in space and perform different movement patterns with growing spatial awareness? In what ways do we assist children to engage in a variety of physical activities and games that use geometric ideas?	How do we encourage children to collect, analyze, and represent data about their physical activity?

As an illustration of the power of the numeracy matrix, consider the column headed by the powerful mathematical idea *Argumentation* that

> allows children … to justify not only their own mathematical thinking but also to distinguish between the strengths of arguments and whether the mathematics being constructed within the arguments is actually different from previous mathematical arguments that have been interactively constructed. (Perry & Dockett, 2002, p. 92)

Providing such justification, while clearly important as children develop their mathematics, is also important in many other areas of learning and certainly contributes in numerous ways to the developmental learning outcomes. On the other hand, the development of this powerful mathematical idea depends on early childhood educators' pedagogical practices, some of which are presented in the form of questions or challenges within the numeracy matrix. For example, in answer to the pedagogical question "How do we encourage children to contribute constructively to mathematical discussions and arguments?" one of the SNI early childhood educators suggested:

> We would firstly need to make sure that children felt safe in talking up about their solutions and those of others. We want them to say what they think but in ways that will not hurt anyone. That will depend a lot on the atmosphere in the group, but it will also need the kids to know the maths that they are talking about.

The contribution of each powerful mathematical idea to the developmental learning outcome *Children are intellectually inquisitive* also provides an example of the power of the matrix. While few of the early childhood educators involved in SNI would have argued against mathematics contributing to this DLO, none was able to articulate how that might occur in a learning area such as mathematics with its perceived underlying (and constraining) structure. Through their use of the numeracy matrix, the educators are now able to see how each of the powerful ideas contributes to the DLO. One of them was able to suggest that the work with the

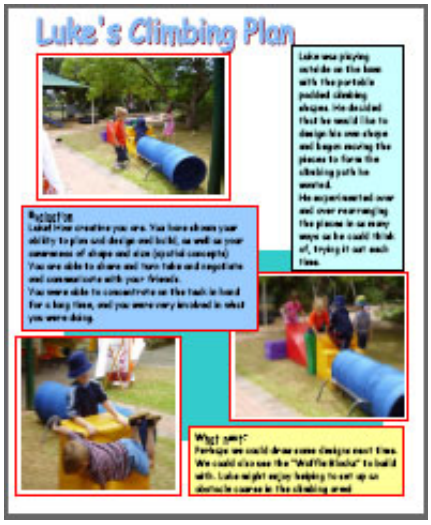
numeracy matrix had helped them see how the DLOs were the capstones to all that they were trying to do in all learning areas:

> When I thought about shapes and geometry, I thought all that was needed was for the children to know the names of some regular shapes. It was really not something I thought they would be inquisitive about. By using the matrix, I can see that they can develop their inquisitiveness by asking lots of questions about lots of different shapes in their environment—not just triangles and circles—and can investigate why things are the way they are. This will take them into asking about how things are used, where they come from, whether some shapes are better than others for a particular job, and why some shapes look better than others. It is exciting for the children—and for me!

Learning Stories and the Assessment of Powerful Mathematics Ideas

The approach to assessment known as *Learning Stories* has been pioneered by Carr (2001). *Learning Stories* are qualitative snapshots, recorded as structured written narratives, often with accompanying photographs that document and communicate the context and complexity of children's learning (Carr, 2001). They include relationships, dispositions, and an interpretation by someone who knows the child well. They are "structured observations in everyday or 'authentic' settings, designed to provide a cumulative series of snapshots" (Carr & Claxton, 2002, p. 22). Learning stories acknowledge the multiple intelligences and holistic nature of young children's learning, educators' pedagogy, and the context in which the learning takes place. Educators use their evaluation of the learning story to plan for future, ongoing learning. In South Australia, learning stories have been used by preschool educators for some time, especially in the area of literacy learning. However, they tended not to be used in the area of mathematics, partly because the preschool educators did not have sufficient confidence in their ability to link what they were observing with mathematical learning outcomes. The introduction of the numeracy matrix has given this confidence to the group of educators working with the authors and has produced some outstanding results. Two mathematical learning stories illustrate this point:

View PDF of "Luke's Climbing Plan" (pictured right)



Luke's Climbing Plan

Luke was playing outside on the lawn with the portable padded climbing shapes. He decided that he would like to design his own shape and began moving the pieces to form the climbing path he wanted.

He experimented over and over, rearranging the pieces in as many ways as he could think of, trying it out each time.

Evaluation
Luke! How creative you are. You have shown your ability to plan and design and build, as well as your awareness of shape and size (spatial concepts).

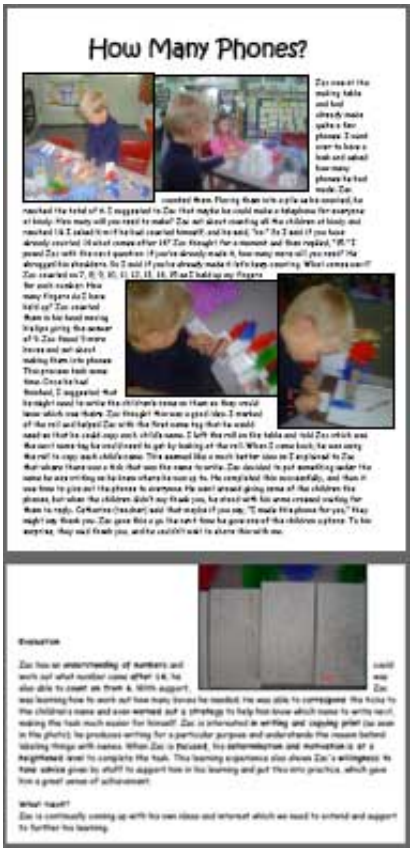
You are able to share and turn take and negotiate and communicate with your friends.

You were able to concentrate on the task in hand for a long time, and you were very involved in what you were doing.

What Next?
Perhaps we could draw some designs next time. We could also use the "Waffle Blocks" to build with. Luke might enjoy helping to set up an obstacle course in the climbing area!

There are clear links between the learning story *Luke's Climbing Plan* and the numeracy matrix. The most obvious is the link between the DLO *Children develop trust and confidence* and the powerful mathematical idea*Spatial and Geometric Thinking.* Luke has been given the opportunity, through the provision of time, materials, and space, to "participate purposefully in spatial tasks" and to "demonstrate flexibility and to make choices." The educator's suggestions for What Next are derived from the pedagogical question "What do we do to encourage children to use visual representations in recording their spatial thinking?" from the cell linking the DLO *Children develop a sense of being connected with others and their worlds* and the powerful mathematical idea *Spatial and Geometric Thinking.* In terms of mathematical processes, one example of a link to Luke's play through the numeracy matrix is the pedagogical question "How do we encourage children to play and interact purposefully with the mathematics they experience in their lives?" in the *Children develop trust and confidence*and *Connections* cell. One important aspect of this encouragement is assisting the children to recognize the mathematical ideas that they are experiencing in their lives. To do this, the children need to be introduced explicitly to the mathematical vocabulary needed to describe these ideas. Without sufficient language to communicate the ideas being developed, children will be at a loss as to how to interact with their peers and their teachers and, therefore, will have the opportunities for mathematical development seriously curtailed (Cobb, Yackel, & McClain, 2000). In short, children need sufficient language to allow them to understand their peers and their teachers as explanations are presented, and to allow them to give their own explanations.

View PDF of "How Many Phones?" (pictured right)


How Many Phones?

How Many Phones?

Zac was at the making table and had already made quite a few phones. I went over to have a look and asked how many phones he had made. Zac counted them. Placing them into a pile as he counted, he reached the total of 6. I suggested to Zac that maybe he could make a telephone for everyone at kindy. How many will you need to make? Zac set about counting all the children at kindy and reached 14. I asked him if he had counted himself, and he said, "no." So I said if you have already counted 14 what comes after 14? Zac thought for a moment and then replied, "15." I posed Zac with the next question: if you've already made 6, how many more will you need? He shrugged his shoulders. So I said if you've already made 6 let's keep counting. What comes next? Zac counted on 7, 8, 9, 10, 11, 12, 13, 14, 15 as I held up my fingers for each number. How many fingers do I have held up? Zac counted them in his head moving his lips giving the answer of 9. Zac found 9 more boxes and set about making them into phones. This process took some time. Once he had finished, I suggested that he might need to write the children's name on them so they would know which was theirs. Zac thought this was a good idea. I marked off the roll and helped Zac with the first name tag that he would need so that he could copy each child's name. I left the roll on the table and told Zac which was the next name tag he would need to get by looking at the roll. When I came back, he was using the roll to copy each child's name. This seemed like a much better idea so I explained to Zac that where there was a tick that was the name to write. Zac decided to put something under the name he was writing so he knew where he was up to. He completed this successfully, and then it was time to give out the phones to everyone. He went around giving some of the children the phones, but when the children didn't say thank you, he stood with his arms crossed waiting for them to reply. Catherine (teacher) said that maybe if you say, "I made this phone for you," they might say thank you. Zac gave this a go the next time he gave one of the children a phone. To his surprise, they said thank you, and he couldn't wait to share this with me.

Evaluation

Zac has an **understanding of numbers** and could work out what number came**after 14;** he was also able to **count on from**

6. With support, Zac was learning how to work out how many boxes he needed. He was able to **correspond** the ticks to the children's name and even **worked out a strategy** to help him know which name to write next, making the task much easier for himself. Zac is interested **in writing and copying print** (as seen in the photo); he produces writing for a particular purpose and understands the reason behind labeling things with names. When Zac is **focused,** his **determination and motivationis at a heightened level** to complete the task. This learning experience also shows Zac's **willingness to take advice** given by staff to support him in his learning and put this into practice, which gave him a great sense of achievement.

What Next?
Zac is continually coming up with his own ideas and interest which we need to extend and support to further his learning.

In the *How Many Phones* learning story, the most obvious link to the numeracy matrix is through the powerful mathematical idea *Number Sense and Mental Computation.* Zac's efforts show a strong understanding of some aspects of number beyond what most 4-year-olds could be expected to have. However, the educator's interventions with Zac are where the strength of the numeracy matrix can be seen. For example, the suggestion that Zac tell each of the other children about the phones links with the DLO *Children are effective communicators,* while the extension of the child's activity to the making of a phone for all the children could have been stimulated by the question "What opportunities do we provide for children to seek new challenges and persist in their problem solving?" in the *Children develop a positive sense of self and a confident and personal group identity* and *Number Sense and Mental Computation* cell.

Conclusion

The purpose of this paper was to introduce the numeracy matrix, which has been developed as part of the Southern Numeracy Initiative in South Australia, and to celebrate the work of the early childhood educators who have been involved in its development. Anecdotal evidence from the participants in the Southern Numeracy Initiative suggest that the use of the numeracy matrix and the thinking behind it have had positive effects on the pedagogical practices of the early childhood educators involved. The learning stories assessment methodologies have allowed the preschool educators to meet their reporting obligations while at the same time remaining true to their early childhood philosophies. These results suggest that the SNI preschool project will lead to improved practices and, consequently, improved learning outcomes for the children who are fortunate enough to be taught by this enthusiastic group of educators.The following comments from preschool educators in the project provide evidence that the approaches constructed during the professional development program have helped answer the overall research question for the project "How can the powerful mathematical ideas that are displayed by young children before they start school be recognized and celebrated in a valid manner within the context of a mandated reporting regime and a child-centered, play-based approach to learning?":

> The numeracy matrix has helped me to rethink the way I am teaching and the way children are learning at my center. It is a useful document in the planning and evaluation not only of children's learning but in your own teaching pedagogy. It poses questions that look not just at the skills that children are required to have in numeracy but it looks deeper into "how" and "what" we do to encourage and provide opportunities for children to experience and develop mathematical understandings.
>
> Using the matrix and being able to develop one inquiry question and explore it in depth has illustrated to me how and when to assess children in a variety of ways.

My ability to focus on mathematical learning and extend individual children's learning, as well as assess it positively in learning stories, is quite empowering.

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