

## **Emma's story: A case study of a toddler's problem solving development**

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*Problem solving is an essential life skill developed very early in our lives, and in a variety of ways. Toddlers (approximately 12 months to three years of age) and very young children have an innate desire to explore their worlds and as they do so encounter many ways that may assist them in their quest for knowledge and skills. This paper examines some of the literature surrounding problem solving and discusses evidence that toddlers do engage in solving complex problems as a foundation for future mathematical understanding. This empirical evidence is based upon a case study of a child, in the toddler stage, observed in her own home.*

### **Introduction**

If children are to grow cognitively and develop skills in mathematical domains, they must encounter problems, attempt to solve these problems, and see the results of their attempts in a context that is relevant and meaningful for each individual child. Very young children have an often surprising mathematical ability, which occurs and develops in a natural way (Copley, 2000). Problem solving is not easy to define precisely as there are many theorists, authors, researchers, teachers, and parents who have contributed to the wide range of literature surrounding this topic, and in many forms. Problem solving per se has usually been defined within a mathematical, logical, or puzzle oriented context (Corneille, 1997). However, there is evidence within the literature that children in the toddler stage encounter and solve problems every day in a natural, normal, and meaningful way as long as they have the space, time and physical ability to do so (Corneille, 1997; Geist, 2001).

### **Background Discussion**

Literature was used to inform a case study of one toddler's problem-solving experiences. Toddlers develop problem solving skills and competence through engaging in experiences and the natural maturation of a wide range of cognitive and physical skills (Smith, 1998). These include those of reasoning, understanding object permanence and classification of objects, fine and gross motor development, cause and effect, and hand to eye co-ordination (Bredekamp, 1986; Corneille, 1997; Geist, 2001; Goffin & Tull, 1985; Perkins, 2003). Problem solving is also fundamental to

children's development in academic skills, as it forms the foundations for the child's future competency in numerical understanding, reasoning, logic, computation, estimation, spatial awareness and meta-cognition (Goffin & Tull, 1985).

There are a variety of influences and factors that impact upon the development of problem solving skills; the disposition and interests of the child, family/whānau and educational environments, the experiences a child may have had as an infant, relationships with caregivers/parents, and whether the child has a disability or special ability in any domain.

The recent debate and research on human brain development presents understanding of the way in which the human brain develops knowledge connections. The first three years of a child's life are paramount to the child's future learning, and this research shows that problem solving begins to develop at a very early age (Newberger, 1997; Shore, 1997). According to Fancourt (2000) curiosity in solving problems, as a natural aspect of human cognition, must be encouraged and enhanced from birth. This can be fostered through ensuring that children are raised and educated in emotionally safe and warm environments. There is evidence collated through the brain development research that indicates that human beings have *critical windows of opportunity* (Shore, 1997) where there are optimal times when certain domain specific skills can be learnt and the ensuing brain connections (or *synapses*) are formed and strengthened. For the skills and interest in mathematics and logic, the research indicates one year to four years as the optimal time to formulate the connections that establish these skills (Fancourt, 2000; Newberger, 1997; Shore, 1997); these years are the infant and toddler years.

### **Theoretical Frameworks**

Alongside brain development research is the theoretical and pedagogical understanding, and underpinning, of the ways in which children learn. There are a variety of theoretical frameworks that have been used to describe the actions and thinking a child may develop. The following discussion outlines some of these as applicable to the case study approach taken.

Bronfenbrenner (1979) discussed the theory of children's development through the *ecological model* which encompasses the manner in which children develop skills and knowledge firstly within their immediate environments, which are in turn affected by the next and subsequent levels of influence through wider environments such as educational setting or community (Smith, 1998). In the light of this ecological theory children would initially develop problem-solving skills within their closest environment, usually the home.

Another theoretical approach is that of Jean Piaget's stages of cognitive development. The *sensori-motor stage* (Piaget) is evident in the problem solving skills of toddlers as they manipulate objects using their senses. This is particularly evident when children classify objects by mouthing, touching, tasting, seeing and hearing. These classification skills enable children to begin to understand the properties of objects, matching like objects, and forming their own knowledge of the characteristics of these objects (Geist, 2001). This cognitive development occurs when children interact with their immediate environment causing engagement in reasoning, logic, decision-making and prediction. Consequently these problem solving approaches foster independence and curiosity in children, important life skills (Goffin & Tull, 1985).

A third theoretical approach is that of a sociocultural perspective which can sit alongside the ideas of Piaget and Bronfenbrenner. Vygotsky (Smith, 1998) stated that children learn best through a socially constructed environment and where 'more expert' peers or others engage children in experiences, which could stretch the realms of possibility in manipulating and solving problems. Therefore, in a sociocultural (Vygotskian) environment toddlers would attempt to solve problems alongside others as their main source of learning. This notion is challenged by Smith (1998) as inappropriate as she states that according to toddlers' levels of development they must explore their worlds in an autonomous manner before they have the social skills that would enable them to engage in experiences with other children.

Rogoff (1995), a more recent theorist, has been described as a 'neo Vygotskian' because of the ways in which she introduced new perspectives on sociocultural theory. She discussed the interrelated nature of children's experiences, with others and with themselves, in learning and development and used the term *apprenticeship*

to describe the particular practice and repetition of the early learning of the very young. Rogoff also coined the term *guided participation* to explain the relationships between people as they come to shared understanding. This could be child to child, child to adult, or adult to child.

Bruner (1973) took a different stance in terms of developing problem solving skills. He stated that from the earliest months of life the child is a *natural problem solver* that is seen as the child making sense of their own world in a way that is meaningful to them. In contradiction to others' views of the child, Bruner strongly believed that even very young children could tackle (and succeed) in solving complex problems.

### **Environmental Influences**

For very young children opportunities to problem solve do not need to be within a contrived environment. Simply moving through the routines of a 'normal' day can prove challenging for children. The key aspects for children, and those who facilitate environments for children, are time and space to explore in an open-ended, and adult supported, manner (Britz, 1993). Providing an environment rich in opportunities for problem-solving should include the notion of the adult as a learner alongside children, observing, assessing, evaluating, listening and questioning, but also understanding the goals and processes involved in a child centred curriculum (Bredekamp, 1986; Haynes, 2000a). Assessment and planning practices for toddlers must make reference to problem solving opportunities that have traditionally been ignored as an important area of development for toddlers (May, 2003). Adults working within the field of early childhood education must ensure that they have a comprehensive understanding of physical and cognitive development of toddlers and the special nature of children at this stage. This includes knowledge of toddlers' need for large muscle activity (gross motor experiences) and active participation in figuring out their place in the world (Babbington, 2003; Haynes, 2000b).

Working alongside others at the later stages of toddlerhood often manifests itself in symbolic, imaginative play where children imitate the actions and interactions of themselves and those around them (Gowen, 1995). When children attempt to imitate these actions problems begin to occur and children must make reasonable and logical choices with regards to roles, resources, and courses of action (Bruce, 1995). "It is

important that teachers and parents realise that when children play imaginatively they are not being frivolous but are practicing important intellectual and social skills, which will help them develop in many areas” (Smith, 1998).

Toddlers require a wide variety of tangible experiences and play in order to develop skills in problem solving. These experiences are best focused upon children’s interests and situated within a play-based curriculum (Gowen, 1995). Children’s routines must also remain familiar and predictable so that children feel able to participate without fear of the unknown interfering with attempts to try out problem solving strategies (Ministry of Education, 1996).

One of the current trends in defining types of play that fosters high-level problem solving learning for children is *heuristic play*. This particular type of play is centred on children having free access to manipulate, in any way they choose, everyday objects and artefacts. Fundamental to play being defined as ‘heuristic’ are the resources, the hands-off adult role, undisturbed and calm periods of time for the play to occur, and enough equipment for every child to explore every item should they wish to. “Heuristic play is the play that allows children to experience and put together objects in a way that engenders an excited feeling - ‘I have found out about this object’” (Auld, 2002, p. 36). Exploring, and subsequently discovering, the properties of objects has a strong link to mathematical skills as children may classify these objects by their attributes; early geometry (Babbington, 2003).

New perspectives of the world occur with the onset of mobility, (usually early in the toddler stage). This creates different problems, as at this time of rapid physical and cognitive development children require tangible experiences upon which to base their explorations. These experiences must challenge and excite the child in order to foster learning of, and about, problem-solving (Geist, 2001; Goffin & Tull, 1985).

## **Method**

Data was collected over an eighteen month period of one child’s life aged from eight months to two years. The child, Emma, is an only child of a two-parent family of which the father is self-employed and the mother is an at-home parent.

Two methods of observation were used by the researcher; running records and narrative accounts, which were all situated in the child's home. In addition anecdotal diary accounts were recorded by the child's mother; both at home and in community settings.

### **Findings and Discussion**

The following accounts are a synopsis of the actual observations and analysis of Emma's problem solving development over the period of the study.

#### *Emma aged eight months (infant): A running record*

In this situation Emma had an interest in exploring her immediate environment and was able to manipulate objects using her body. She was able to move unwanted objects out of the way to gain access to those she desired and seemed to have an interest in objects that fitted together or formed a distinct set (three puzzle pieces). Emma was clearly in the sensori-motor stage of development (Piaget, 1965) as she explored the objects she chose with her mouth and hands feeling the attributes of each, and seeming to decide that the wooden puzzle pieces belonged together. She was able to solve problems as she encountered them by manipulating objects through manoeuvring her body to move unwanted objects out of the way of the desired ones as a *natural problem solver* (Bruner, 1973).

#### *Emma aged thirteen months (toddler): A narrative account*

Here, Emma was able to complete two out of three different puzzles by manipulating the pieces into the frame through using trial and error. At first she explored each of the pieces of the three puzzles and seemed to be figuring out the attributes of each through touch. These actions can be analysed as *sensori-motor* (Piaget, 1965) as Emma was using her senses to construct knowledge about the pieces. This also links to the *apprenticeship* stage (Rogoff, 1995) as Emma was practising the skill of completing puzzles, which she had experienced in other environments such as the Playcentre she attends with her mother. Hence applying the knowledge that she had gained in her *macro system* in her *micro-system* (Bronfenbrenner, 1979). Emma's physical development and comparative dexterity (compared to her development in the infant stages) meant that she had the physical skills to manipulate the pieces of the puzzle in order to complete it (Smith, 1998). The confusion of completing the third

puzzle was easily solved when Emma gained some assistance from her mother clearly showing the notions of *guided discovery* (Rogoff, 1995) and *scaffolding* (Smith, 1998) when her mother made the suggestion to rotate the final piece. Emma also showed skills and dispositions of decision-making, curiosity, perseverance and reasoning (Goffin & Tull, 1985) which confirms that she was working within her immediate environment using skills she had gained in her 'major' settings such as Playcentre, home, and in the community (Ministry of Education, 1996).

*Emma aged nineteen months: A narrative account*

In this observation where Emma was engaged in a cooking experience with her mother, many problem solving skills were apparent. She was able to show her knowledge of her home environment by indicating the place where items for cooking were located (the kitchen pantry). She was able to move objects out of the way so that she could gain access to the desired ones and she did this by placing these on the chair at her feet clearly showing that she was able to solve this problem independently. Emma was able to place these objects on the chair by balancing them at her feet and carefully manoeuvring her body to gain access to those which she had been asked to retrieve. This use of prediction and thinking through a problem without the need to gain assistance shows the beginnings of the *pre-operational* stage of development where children are able to think in symbolic forms and perform cognitive operations (Piaget, 1965). This is also evident when the butter and sugar mixture spilt onto the bench and Emma was able to carefully collect this and place it back into the bowl when her mother asked her what she should do. She made the decision to do this without being told that that was where it should go. The *pre-operational* stage of development (Piaget, 1965), is also evident when Emma's mother told her that the biscuit dough needed to be rolled into balls and she fetched her own red ball from her room. This symbolic understanding shows Emma's ability to make comparisons between ideas and objects and her knowledge of the spherical shape. Emma attempted to roll the biscuit dough and had difficulty in doing so. When she found that this was too hard for her she asked for help from her mother. She watched her mother do this and then tried again but her fine motor skills were not yet developed enough to manipulate the dough into balls. Her mother acknowledged and accepted her attempts as valid and she seemed content with this. This acceptance of her attempts to roll the

dough was an important aspect of her problem solving development as her interests in cooking and helping her mother were fostered and reinforced (Gowen, 1995).

*Emma aged two years: Excerpt taken from a diary account*

These anecdotal records of Emma's engagement in the problem of dressing herself, her dolls and teddy and assisting others to dress showed a depth of engagement in problem solving incidents. An attempt by Emma to dress herself showed her increasing need for autonomous behaviour, clearly linking to development in the *pre-operational* stage as she was able to re-enact dressing from previous experiences (Piaget, 1965).

In another incident Emma was able to solve her Playcentre friend's problem of not being able to dress a doll by using the knowledge and experience of the previous day to assist her. This example of *guided participation* (Rogoff, 1995) and construction of knowledge within a social environment showed Emma's developing skill in reflection, offering support to others and using her previously gained skills to solve a problem (Britz, 1993). A third incident showed further reflection and development of skill. Emma was able to dress her dolls and teddy with verbal guidance at first and then without guidance as she repeated the learnt skill. This practice and repetition of a *scaffolded* (Bruner, 1973) skill shows her rapid development of problem solving to reach a desired goal.

### **Conclusion**

There are many examples of mathematics within Emma's story. Her classification of the puzzle pieces as she located them into the correct slots on the boards provided a clear link to concepts of location and position, which are aspects of early geometry. By comparing the sizes of the clothing in the family corner Emma was able to communicate her increasing knowledge of the measurement concepts of size and seriation. These examples show how she developed understanding, in her own way, and at her own pace (Copley, 2000). The continuing development of problem solving skills throughout infancy and toddlerhood forms strong foundations for future success and skills in mathematics.

Over the observational period Emma developed a variety of problem-solving skills including manipulating and completing puzzles, dressing herself and others, and using reflection as a process to solve subsequent problems. Working alongside others at the later stages of toddler hood often manifests itself in symbolic, imaginative play where children imitate the actions and interactions of themselves and those around them (Gowen, 1995). Her problem solving continues to develop and the knowledge gained will ensure that she now has new skills to solve further problems as she encounters them. This in turn may lead to further interest in mathematical problem solving as she classifies, measures, compares, positions and counts objects she is interested in.

If children are to become confident problem solvers they must be encouraged to start from birth in the exploration of their environments. They need to have tangible, hands-on experiences in order to discover how things work, what they are, what they are not, and to be able to compare, contrast and classify. It is also important for children to be able to reason, develop logic, and engage in a reflective process. These aspects of development form a sound basis for future creativity and the thinking ability to analyse, predict, and formulate new thoughts and ideas.

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